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ABSTRACT

Abstracts of papers presented to the 45th Annual Meeting of the National Association for Research in Science Teaching are arranged according to the topic for the session at which they were presented. Series of sessions were devoted to test and instrument development, evaluation, learning theory, verbal behavior, instructional methods and materials, student achievement, and teacher preparation. Single sessions were held for the presentation of research papers on teacher characteristics, student characteristics, and the history and philosophy of science. Abstracts of addresses to general sessions (on various aspects of science education research) by Raths, Sutman, and Broudy are included, as well as lists of the participants in two symposia (environmental education and the problems of beginning teachers). Papers on elementary, secondary, and college level science education are included for most topics. (AL)

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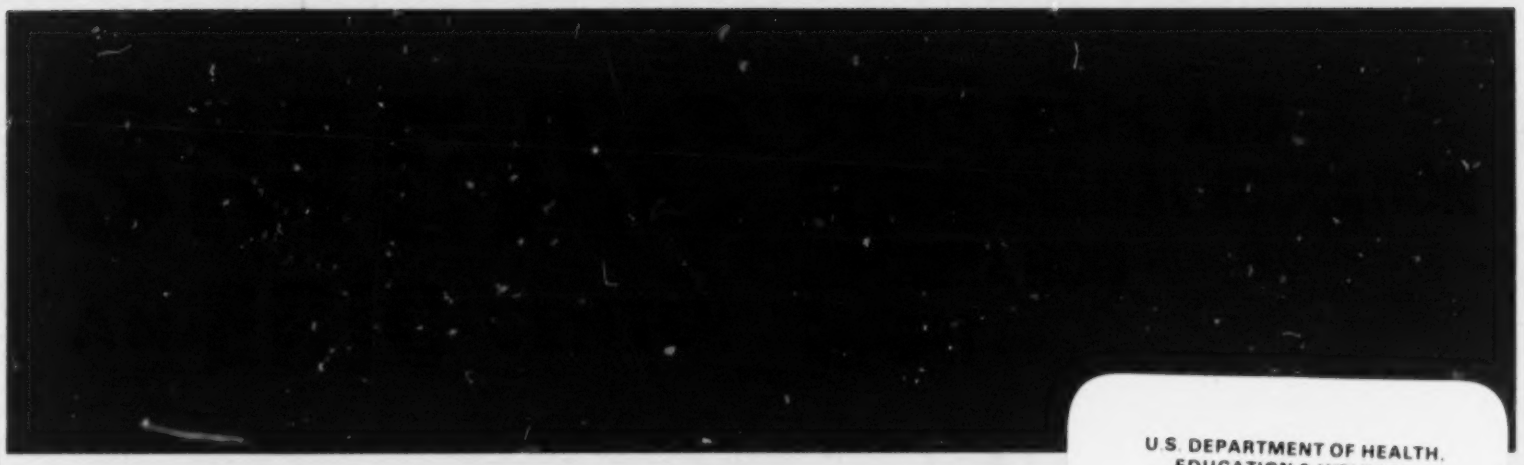

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NATIONAL ASSOCIATION

FOR RESEARCH IN SCIENCE TEACHING

45TH ANNUAL MEETING

ABSTRACTS OF PRESENTED PAPERS

Sheraton Blackstone Hotel
Chicago, Illinois
April 4-6, 1972

PREFACE

The ERIC Information Analysis Center for Science, Mathematics, and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Chicago, Illinois, April 4-6, 1972.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC Staff to provide a general format for the abstracts. Special recognition should be given to Dr. J. David Lockard who organized the program and obtained most of the abstracts, to Dr. Patricia Blosser for extensive assistance in preparing the abstracts, and to Mrs. Maxine Weingarth, Miss Linda Hemmler, and Mrs. Charlotte Helgeson for typing and compiling.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Research in Education and other publications of the ERIC system.

February, 1972

Stanley L. Helgeson
Associate Director
Science Education
ERIC Information Analysis
Center for Science,
Mathematics, and
Environmental Education

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GENERAL SESSION I

Chairman: Frank X. Sutman, Temple University, Philadelphia, Pennsylvania

Speaker: James D. Raths, Director, Bureau of Educational Research, University of Maryland, College Park, Maryland

"The Emperor's Clothes Phenomena In Science Education Research"

One problem that seems to stultify the efforts of researchers in the field of science education is their idealization of the precision of research in the hard sciences and their cynicism toward research in science education. This paper explores ways these rather extreme reactions might be modified through reconceptualizing the potentialities and limitations of empirical research. Also addressed is the problem of transferring the scientific approach to problems from the laboratory or classroom to the real life of the teacher.

CONCURRENT SESSIONS I

Session Ia - Test and Instrument Development, Envoy Room

Chairman: Ronald D. Anderson, University of Colorado, Boulder, Colorado

1. "Test-Construction Behavior of Pre-Service Secondary Science Teachers," H. James Funk, Indiana University at South Bend, Indiana.

2. "The Development, Field Test and Validation of Scales to Assess Teachers' Attitudes Toward Teaching Elementary School Science," Richard W. Moore, Miami University, Oxford, Ohio.

3. "The Development of An Objective Science Process Test for Elementary Teachers," Evan A. Sweetser, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, and Wayne Taylor, Michigan State University, East Lansing, Michigan.

TEST-CONSTRUCTION BEHAVIOR OF PRE-SERVICE SECONDARY SCIENCE TEACHERS

H. James Funk
Indiana University
South Bend, Indiana

This study was undertaken to determine the effects of instruction in the use of the Taxonomy on the attitudes and test-construction behavior of prospective secondary science teachers. Four research questions were posed: (1) Do the subjects' grade point averages or majors affect their test-construction behavior during the methods course and during student teaching? (2) Does instruction in the use of the Taxonomy cause a change in attitude that persists through the student teaching assignment? (3) Do the subjects' attitudes toward the Taxonomy affect their test-construction behavior? (4) Does the subjects' test-construction behavior differ from the test-construction behavior of a population of science teachers?

The study population consisted of secondary science majors who enrolled in the methods course and student teaching. Sample tests were collected from the subjects during the methods course and during the student teaching assignment. Items on the 219 tests were classified according to the Taxonomy. Attitude data were obtained using a Word Association Scale, a modified semantic differential. Pre-instructional, post-instructional, and delayed post-instructional measures were obtained.

The subjects were blocked on two levels of GPA, two levels of repeated measures on the criterion variable (i.e., proportion of knowledge level items on the tests), three levels of major (i.e., physical science, biology, and general science), and subjected to a factorial analysis of variance. Attitude data were analyzed using t-tests for significance. The significance level was set at the .05 level of confidence.

No significant differences in proportions of knowledge level items on tests were found between levels of GPA. Tests prepared by physical science majors contained significantly lower proportions of knowledge level items than tests prepared by biology and general science majors. The tests prepared by student teachers contained larger proportions of knowledge level items than the tests they prepared during the methods course. The attitude data indicated that instruction had caused a statistically significant positive change in attitude that was maintained during the student teaching experience. Negative correlations between proportions of knowledge level items on tests and attitude scores were observed; however, none were statistically significant. The comparison of tests prepared by the subjects to tests prepared by the population of science teachers revealed that the tests prepared by the study population contained a lower proportion of knowledge level items.

THE DEVELOPMENT, FIELD TEST AND VALIDATION OF SCALES TO ASSESS TEACHERS' ATTITUDES TOWARD TEACHING ELEMENTARY SCHOOL SCIENCE

Richard W. Moore
Miami University
Oxford, Ohio

The purpose of this study was to prepare and demonstrate the use of a valid and reliable instrument to use in assessing the attitudes of elementary school teachers toward science teaching.

The positions to be assessed were identified. Then, a pool of attitude statements to be used in assessing the extent to which these positions are accepted or rejected was prepared. The responses of a panel of judges and a group of teachers to the attitude statements were used as a basis for selecting the five best attitude statements for use in each scale in the Science Teaching Attitude Scales.

The Scales were field tested with a group of 31 CCSS teachers in Butler County, Ohio. They were administered as a pre-pre-test in the spring of 1971, as a pre-test at the beginning of a four-week summer (1971) CCSS project, and as a post-test at the end of the summer project. The difference from pre-pre-test to pre-test was not significant; the difference from pre-test to post-test was significant beyond the .01 level. The reliability (0.816) and the construct validity of the Scales were demonstrated through this study.

The Science Teaching Attitude Scales were developed in the same way as the Scientific Attitude Inventory. Using scales from these two instruments, the author prepared an instrument to assess the science attitudes and the science teaching attitudes of elementary school teachers.

THE DEVELOPMENT OF AN OBJECTIVE SCIENCE PROCESS TEST FOR ELEMENTARY TEACHERS

Evan A. Sweetser
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

and

Wayne Taylor
Michigan State University
East Lansing, Michigan

Science process skills are the central focus of the AAAS-Xerox elementary science program Science--A Process Approach. The program identifies the following eleven process skills as being basic to elementary science education communications, using numbers, observing and measuring, using space/time relations, inferring, classifying, predicting, formulating hypotheses and models, controlling variables, interpreting data, defining operationally. In conjunction with this new science program, the evaluation team of Science--A Process Approach developed a test, "Science Process Measure for Teachers" Form A and Form B, to assess the process skills of the teachers. This test (Form A & Form B were comparable) required the teacher to perform the behavior and complete her response on the response sheet. Most of these were open response construction rather than objective multiple choice items. While such a test can measure creative skills, it is very time consuming to score and is subject to scorer reliability bias.

The 40-item multiple-choice Science Process Test reported here overcomes the above problems. In addition, it allows a greater sampling of each of the process skills.

Multiple-choice items were written to measure each of the eleven process skills. The test was used on both pre-service and in-service elementary teachers. The third revision reported herein was analyzed pooling responses from three in-service teacher workshops (N=103). The response of the 40-item multiple-choice tests were item analyzed with the following results: mean, 21.34; Standard deviation, 5.60; variance, 31.38; mean item difficulty, 48; mean item discrimination, 34; mean point biserial correlation, 32; Kuder Richardson Reliability #20,.7601.

There are still items which could be rewritten thereby giving a potential of increasing the reliability. A complete form B needs to be developed for use in pre-post test situations.

Because of the case of scoring, the "Science Process Test for Elementary Teachers" is a useful and welcome tool in evaluating teachers' science process skills.

Session Ib - Evaluation, English Room

Chairman: Matthew Bruce, Temple University, Philadelphia, Pennsylvania

1. "The Development and Formative Evaluation of The Monte Carlo Integration Computer," Dean A. Wood, Hood College, Frederick, Maryland.
2. "The Development and Evaluation of an Audio-Tutorial Program of Instruction in Learning Concepts of Ecology and Conservation," Richard W. Presnell, University of Wisconsin, Green Bay, Wisconsin.
3. "An Analysis of Present Evaluation Schemes in College Introductory Geology Courses," James N. Albright and Robert Ridky, Syracuse University, Syracuse, New York.

THE DEVELOPMENT AND FORMATIVE EVALUATION OF THE MONTE CARLO INTEGRATION COMPUTER

Dean A. Wood
Hood College
Frederick, Maryland

A special-purpose digital computer has been developed and constructed that utilizes the Monte Carlo integration method of obtaining simulations of chemical processes. The computer, designated as the Monte Carlo Integration Computer (MCIC), is designed as an instructional model for the illustration of kinetic and equilibrium processes. The MCIC has been shown to be capable of quantitatively simulating microscopic, macroscopic, first-order, second-order, consecutive and catalytic kinetic processes and microscopic, macroscopic, Le Chatelier and catalytic equilibrium processes.

The MCIC contains input, memory, control, logic and output circuitry similar in function to conventional digital computers. The MCIC electro-mechanical circuitry utilizes relays as the basic memory unit and rotary stepping switches for memory access and control. The MCIC was constructed from surplus components at a total cost of approximately $500.

Kinetic and equilibrium topics constitute an important component of high school and college chemistry courses. However, the literature indicates that only two reported instructional models are uniquely capable of simulating ten selected kinetic and equilibrium processes. Both of these instructional models utilize Monte Carlo integration teqhniques and incorporate features that greatly inhibit their pedagogical usefulness. The MCIC has been designed to incorporate the rationale of operation of these instructional Monte Carlo models while eliminating many of their pedagogical disadvantages. The MCIC therefore appears to represent a significant contribution to the repertoire of instructional models.

The MCIC and associated educational materials have been formatively evaluated. Questionnaires, designed to obtain written open-responses to selected questions, were administered to high school chemistry students after they had participated in lecture-demonstrations utilizing the MCIC. Remedial procedures were generated from questionnaire diagnoses and implemented in following presentations. In this manner, diagnostic questions, diagnosis and remedial procedures were linked to provide on-going evaluation and feed-back on three presentations of the MCIC. Also, the appropriateness of this formative evaluation has been considered in relation to other possible evaluative models.

THE DEVELOPMENT AND EVALUATION OF AN AUDIO-TUTORIAL PROGRAM OF INSTRUCTION IN LEARNING CONCEPTS OF ECOLOGY AND CONSERVATION

Richard W. Presnell
University of Wisconsin
Green Bay, Wisconsin

The purposes of this study were to design, develop, implement, and evaluate a one year environmental education instructional program emphasizing concepts of ecology and conservation, and environmental interpretative skills to serve as pre-field trip instruction for upper elementary school children. Other objectives were to provide instruction that could: (1) easily be incorporated into existing school curricula by requiring a minimum of teacher-training, time, effort, and expense, (2) be inexpensive in both initial cost and operating expense, and (3) serve as an instructional program for both children and their teachers.

A series of ten, twenty-seven minute, sequential, audio-taped lessons were designed, revised, developed, and replicated in three copies. Four lessons comprised an autumn pre-field trip program, three, a winter program, and the final three made up a spring program.

One hundred thirty-eight children experienced lessons, field trips, and five written production tests. Ninty-eight fifth and sixth graders from a suburban school of the same district experienced three of the five tests, and served as a control. The seasonal field trips employed a discovery technique and a variety of wildlife survey games. They were led by the author in areas adjacent to the instructed students' schools.

Seventeen teachers and four administrators from the three schools played one of a number of program implementation roles. Program assessment devices consisted of five student tests, a twenty-five question school staff questionnaire, and numerous hours of observation of students attending lessons, field trips, and a small group wildlife ecology game designed for use as a winter program supplementary activity.

The design, development, and implementation of the entire program was empirical. The evaluative student tests indicated that many concept, fact, and skill learning gains occurred, but analysis using Fisher's test for significant changes in both correlated and uncorrelated means indicated that few learning gains were significant. Learning gains achieved may have been due to maturation of the students, and the real or apparent failure of lesson input to effect large gains is probably due to inadequacies in lesson content design and/or failure to sufficiently assess student knowledge both prior to and following instruction. Few significant differences in learning gains were found between field experienced and non-experienced students. Although more significant gains were made by fifth graders, all indications are that the program is more appropriate for sixth grade students.

AN ANALYSIS OF PRESENT EVALUATION SCHEMES IN COLLEGE INTRODUCTORY GEOLOGY COURSES

James A. Albright
and
Robert Ridky
Syracuse University
Syracuse, New York

The evaluation of student performances is a problem which confronts the instructor of introductory science courses and which often lies at the heart of student dissatisfaction with higher education. Little data exists concerning the extent to which various personal philosophies of instruction and measurement are being incorporated into evaluation schemes.

A study was undertaken at the close of the 1970-71 academic year to investigate the use of final examinations in introductory geology courses as a measure of student performance. Final exams for introductory courses as well as a response to a questionnaire was solicited from seventy-five colleges and universities in the northeast. The questionnaire requested such information as: who the course was intended to serve, the course enrollment, the portion of the student's grade that the final examination accounted for, the extent of material it was intended to cover, as well as the number of semesters the instructor had taught the course.

One aspect of the study dealt with assessing the examination questions as to the type of intended behavior the question would require of the student, in short, the thinking process required by the student to answer a question. A modified version of the Taxonomy of Educational Objectives - Cognitive Domain was used in categorizing the test questions. The basic guidelines employed were that the information provided by the question and/or answers would be the total resource information with which the student would have to work, and that the terminology used in the question could be understood by the student. Although several levels may have been in operation in a particular question, only the highest level on the Taxonomy was recorded.

A computer program was written for analyzing the data gathered from each exam. A printout showing the taxonomic profile for the instructor's exam as well as a few pages describing the system was returned to the instructor. A taxonomic profile was assembled for the pooled sample. Finally, pooled analyses of the final exam questions received from the introductory courses were compared to the analysis of questions used in the Graduate Record Exam (Geology).

Final examinations in multiple choice format predominated as a means of evaluating student performances in introductory courses. The taxonomic profile for the pooled sample indicated that although all categories are represented, the knowledge division showed the highest frequency. Within the knowledge division itself, a noticeable absence of knowledge questions relating to terminology and methods existed. In this respect, the taxonomic profile for the geology graduate record examination was similar to the taxonomic profile for the pooled sample. No correlation was found between the frequency of higher order questions and either (i) the number of semesters that the course had been taught, or (ii) the course design (majors or non-majors). Although alternate modes of evaluation were reported by the sampled geology departments, the mode of evaluation was not strongly related to course enrollment.

Session Ic - Learning Theory, Regency Room

Chairman: Eugene Lee, Emory University, Atlanta, Georgia

1. "The Relationship Between Selected Conservation Tasks and Drawings Made from Memory by Primary School Children," Martha Camp, University of Iowa, Iowa City, Iowa.
2. "Observation and Comparison Tasks Using Ordinary and Novel Objects," James Barufaldi, University of Maryland, College Park, Maryland.
3. "Procedures for Generating Candidates for Learning Hierarchies," Edward L. Smith, Southwest Regional Laboratories, Inglewood, California.

THE RELATIONSHIP BETWEEN SELECTED CONSERVATION TASKS AND DRAWINGS MADE FROM MEMORY BY PRIMARY SCHOOL CHILDREN

Martha Camp
University of Iowa
Iowa City, Iowa

A study exploring the hypothesis that drawings a child makes from memory are related to his intellectual level on certain Piaget-type conservation tasks was conducted using kindergarten, first, and second grade children in the sample group. The conservation tasks of number and length, as well as a memory task involving an initial visual display of sticks, were administered to all children in the sample. Conservation of number levels was significantly related to the memory drawings, but conservation of length levels was not. It is possible that the sample did not include children of sufficient age to show a relationship between conservation of length levels and the memory drawings.

Each child in the sample selected from a series of drawings one which appeared to him most like the initial visual display. These drawings selected by each child were related to both conservation of number and conservation of length levels.

Data generated in this study were utilized in developing predictive rules for determining conservation of number levels without administering an individual Piaget-type interview. Some success at making predictions was obtained when a combination of variables was used in developing the predictive rule.

Results of this study add to the evidence that the quality of memory is related to the intellectual structures of a child. The study also suggests that techniques of eliciting a child's memory can supply indirect evidence of the kind of intellectual structures that the child employs in his thinking about the physical world.

OBSERVATION AND COMPARISON TASKS

USING ORDINARY AND NOVEL OBJECTS

James Barufaldi
University of Maryland
College Park, Maryland

An important question to be considered by science educators is: Does the familiarity of the object observed by the individual influence his responses on observation and comparison tasks? The aims of this study were to answer three questions.

1. Do children demonstrate greater skill in observing an ordinary object than in observing a novel object?

2. Do children demonstrate greater skill in observing a single object than in comparing two objects?

3. Do children demonstrate greater skill in recognizing similarities in objects than in recognizing differences between objects?

More specifically, the null hypotheses included:

1. There was no significant difference between the number of observations of ordinary objects and the number of observations of novel objects made by children in the same grade.

2. There was no significant difference among grade levels in the performance of children on observation skill tasks.

3. There was no significant difference between the number of observations and the number of comparisons of objects made by children in the same grade.

4. There was no significant difference among grade levels in the performance of children on observation and comparison skills tasks.

5. There was no significant difference between the number of similarities and the number of differences of objects recognized by children in the same grade.

6. There was no significant difference among grade levels in the ability of children to recognize similarities and differences of objects.

Sixty-six randomly selected urban elementary school children in grades one through six were asked to perform four tasks requiring the use of observation and comparison skills. Task 1 was the observation of an ordinary object. Task 2 involved the observation of a

novel object. In task 3 the subject was asked to observe similarities between the novel and ordinary objects. The observation of differences between the novel and ordinary objects was Task 4. Each subject was interviewed individually to administer the tasks. Data were collected via cassette tape recorder. Responses were then tabulated and categorized. The statistical model employed was the two way analysis of variance.

Differences were found between the ability of children to observe and their ability to compare. Children were more skillful in recognizing differences between objects than in recognizing similarities in objects. Children were equally skillful in making observations of an object which they were able to identify as they were in making observations of an object which was novel to them. Greater attention should be given to improving comparison skills and to recognizing similarities in objects. The results of this study suggest that one cannot assume that all children possess the same degree of development of such fundamental skills as observation and comparison.

PROCEDURES FOR GENERATING CANDIDATES FOR LEARNING HIERARCHIES

Edward L. Smith
Southwest Regional Laboratories
Inglewood, California

An important contribution to instructional design is the notion of a learning hierarchy, a set of learning events selected and sequenced to achieve maximum positive transfer from earlier to later attainments. Although many hierarchies have been proposed, the methodology for constructing and evaluating them is still in its infancy. This paper addresses the problem of generating the candidates for learning hierarchies. As a basis for presenting the proposed procedures, the questions of the nature of the entities making up a hierarchy and the nature of the hierarchical relationship are discussed.

The distinction is made between performance requirements or items and skills underlying the carrying out of items. A corresponding distinction is made between two phases of analysis: the analysis of items and item features, and the analysis of skills underlying the performance of a set of items.

A set of procedures is then presented for the item phase of analysis. These procedures are divided into three stages:

(1) Adoption of conventions for describing items in terms of tasks and content.
(2) Definition of tasks.
(3) Specification of content domains for tasks.

Items or item sets can be defined in terms of tasks and content domains. These constitute the range of candidates for inclusion in learning hierarchies and provide the raw material for skill analysis.

Each of the stages is illustrated with products of an analysis of simple object description, comparison and classification. A set of conventions were adopted based on the notion of a variable. The conventions specified the following components in terms of which tasks and content domains were defined: elements, variable names, values, describers, observation/measurement procedures, and correlational rules.

Task parameters and a set of tasks described in terms of the conventions are presented. Many of the tasks generated or suggested by the analysis were not represented in any of the literature reviewed. Sample content domains are presented for the tasks.

The primary contribution of the work reported is the basis it provides for conducting skills analysis and the construction of learning hierarchies. These procedures offer a more systematic and, hopefully, a more powerful approach than simply trying to list the things that need to be learned in order to be prepared to learn a particular new behavior.

The procedures have already been found useful, in systematically generating potential outcomes from which subject matter specialists can select program outcomes on the bases of existing knowledge.

Session Id - History and Philosophy of Science, Ivy Room

Chairman: John Mason, Michigan State University, East Lansing, Michigan

1. "The Development of Skills in Scientific Thinking Through the Use of History of Science Case Studies," John F. Hall, University of Victoria, British Columbia.
2. "Testing a Generalized Approach to Problems Relating Science and Society," Bernice E. Essenfeld, Irvington High School, Irvington, New York.
3. "The History of the Development of the Earth Science Course in the Secondary Schools of New York State: 1894 to 1966," Efrom Blank, New York University, New York City, New York.

THE DEVELOPMENT OF SKILLS IN SCIENTIFIC THINKING THROUGH THE USE OF HISTORY OF SCIENCE CASE STUDIES

John F. Hall
University of Victoria
British Columbia

The purpose of the study was to evaluate a series of 11 history of science case studies designed to teach the following abilities involved in scientific thinking:

1. Recognizing problems, hypotheses, experimental conditions, and conclusions.
2. Understanding the relationship of evidence to hypotheses.
3. Understanding experimental conditions and the control of variables.
4. Making conclusions.
5. Interpreting data.

The population consisted of the entire enrollment of first year education students in a general science course at the University of Victoria. The experimental group included 156 students randomly selected from this population to read history of science case studies. The control group included 154 students randomly selected from the same population to read a science textbook. The experimental group answered questions in the case studies related to the objectives stated above, and participated in two one-hour discussions which dealt with these questions. Other than the use of the case studies, the treatment of the control group and the experimental group involved the same activities. Since the treatment groups were randomly selected, possible extraneous variables related to individual differences and teaching method would apply similarly to both groups.

The Burmester Test of Aspects of Scientific Thinking was administered under standardized conditions to both treatment groups at the end of the semester devoted to this study. This test was designed to measure the same five abilities mentioned above as case study objectives. Mean test scores for the two treatment groups were compared by analysis of variance, using the sex of the student as a covariable.

The mean test score of the experimental group was significantly higher ($P = 0.023351$) than the control group on the total Test of Aspects of Scientific Thinking. Although mean scores on each of five sub-tests on the Test of Aspects of Scientific Thinking favored the group reading history of science case studies, a wide range in levels of significance was found. This indicates that some skills involved in scientific thinking were better developed through the

use of case studies, even though the number of questions and time spent on each skill were approximately equal.

The superiority of the case study group was most pronounced on the sub-test on the ability to make conclusions (P = 0.020979).

Mean test score differences approaching statistical significance included the sub-test on understanding experimental methods and the control of variables (P = 0.101150) and the sub-test on recognizing problems, hypotheses, experimental conditions and conclusions (P = 0.115221). Differences between treatment groups were much smaller on the sub-tests on data interpretation (P = 0.381905) and on understanding the relationship of evidence to hypotheses or possible solutions to a problem (P = 0.746172).

The results of this study indicate that the history of science case studies used in this investigation are more effective than a science textbook in teaching scientific thinking and can be used practically in a university level science course with a large student enrollment. These case studies seem to be most effective in developing the ability to make conclusions, although longer term studies are needed to further assess trends indicated in the data.

TESTING A GENERALIZED APPROACH TO PROBLEMS RELATING SCIENCE AND SOCIETY

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Irvington High School
Irvington, New York

In response to a widespread recommendation on the part of educators, scientists, philosophers, students, and people in government for education in science to be provided within a social context, a science program for seventh grade students was developed based on this philosophy and its effects were tested. The problem under consideration was stated as follows: How does the development of laboratory and class work in Junior High School Science within the context of socially significant problems affect the following:

1. Students' attitudes toward science?
2. Students' attitudes toward scientific careers?
3. Students' attitudes toward science as a school subject?
4. Acquisition of basic knowledge of science?
5. Application of knowledge involving socially significant problems?

It was hypothesized that students in an issue-centered course would show a growth in positive attitudes toward science, scientific careers, and science as a school subject; an increase in ability to apply the knowledge regarding socially significant problems; and no difference in the acquisition of knowledge when compared with a control group studying science without an issue-centered approach.

The program was based on the Jacobson model for a generalized approach to problems and the Andrew model for issue-centered science. To fulfill the requirement of relevancy, a poll of seventh grade students was made in order to ascertain the social issues they considered important. Two instructional programs were written, an issue-centered, generalized, experimental science program, and a control program not involving the issue-centered generalized approach. Except for the social context, both programs were similar in content and materials. Activities were trial-tested and manuals for the two programs were duplicated. The subjects were randomly selected for the two groups. Statistical tests showed the thirty-one students in the experimental group and the thirty-one students in the control group to be one population.

Pre- and post-testing using the Allen Test, Attitude Toward Science and Scientific Careers, and the Silance and Remmers Test, Attitude Toward Any School Subject, were conducted. Upon completion

of the program, structured taped interviews were carried out, and teacher-made tests of knowledge and application of knowledge were administered. Analyses of the data showed:

1. Significant difference in application of knowledge regarding social issues, the experimental students indicating greater ability to apply knowledge to life situations.

2. No significant difference in acquisition of knowledge of basic science program. This was considered a positive result in that the gain of knowledge by the experimental group was the same as the gain of knowledge by the traditional control group.

3. No significant difference in attitude toward science, scientific careers, and science as a school subject. It was suggested that this may have been due to high initial scores in both groups.

4. All of the students interviewed on tape expressed the desire to include socially significant problems in their science course. This was considered positive indication of the desirability of the program.

Implications for further research include development of more curriculum materials using the generalized approach, determining the extent of carry-over of the generalized approach to other areas, probing more questions which involve attitude change, and developing and testing instruments to monitor student feelings.

Implications for education involve use of the issue-centered generalized approach for science studies, further use of techniques to obtain and react to student opinion, and development of techniques to strengthen and extend the capabilities of the classroom teacher.

THE HISTORY OF THE DEVELOPMENT OF THE EARTH SCIENCE COURSE IN THE SECONDARY SCHOOLS OF NEW YORK STATE: 1894 TO 1966

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New York City, New York

The author used the historical method of research to survey briefly the origin and early development of the New York State earth science course from 1853 to 1894, to determine the aims, content, methods and enrollment in New York State earth science classes from 1894 to 1966, to account for changes in the course in terms of changes in contemporary American educational thought -- especially in the work of the New York State Science Teachers Association and educational administrators of New York State, and to examine the consequence of changes in educational thought, aims, content, and methods in terms of changes in enrollment in the earth science course.

It was hypothesized that changes in student enrollment resulted from a combination of the work of the New York State Science Teachers Association and educational administrators in New York State, and that changes in aims, content, and methods of instruction affected student enrollment.

An examination of earth science course enrollment data revealed four periods of major changes in enrollment: a sharp decrease between 1904 and 1907, an increase from 1911 to 1915, 1946 to 1950, and 1958 to 1963. The period between 1907 and 1946 generally marked a long gradual decline in earth science course enrollment as compared to the total secondary enrollment of New York State.

Examination of syllabi, Regents examinations and textbooks revealed that major changes in the earth science course occurred in the following years: 1897, 1900, 1902, 1903, 1905, 1906, 1921, 1922, 1939, 1940, 1941 and 1959.

Nationally, changes in educational thought were identified as having occurred in 1894--the Committee of Ten Report, 1918--the Commission on Reorganization, 1932--NSSE Yearbook, 1944, NASSP--Ten Imperative Needs of Youth, NSSE Yearbook, 1952--NEA Commission on Life Adjustment Education, 1956--The beginning of national programs to improve specific science courses 1959--NSSE Yearbook 1964--ESCP introduced nationally.

It was concluded that only in the first period of enrollment change is there a strong relationship between what New York State educators did and what happened to course enrollment; for the second and third periods no clear relationship exists between the above two factors. In the last period the work of educators and administrators can only partially account for the increase in enrollment.

Additionally it was concluded that in the early history of the course a relationship seems to exist between enrollment and changes in aims, content and methods. After 1905 changes in the course were not accompanied by enrollment changes. When enrollment changes did occur they were not related to major changes in the earth science course, therefore no clear relationship exists between changes in enrollment and changes in the earth science course.

CONCURRENT SESSION II

Session IIa - Test and Instrument Development, Ivy Room

Chairman: Leslie Trowbridge, University of Northern Colorado, Greeley, Colorado

1. "The Use of Student Rationales in Developing a Multiple Choice Test Solutions Guide," Gerald Abegg, Newton College of The Sacred Heart, Newton, Massachusetts.
2. "Development of the Science Process Skills Test (SPST)," Loretta L. Molitor, Towson State College, Towson, Maryland.
3. "The Development of an Instrument to Evaluate Sixth and Ninth Grade Students' Attitudes Toward Science and Scientists," La Moine L. Motz, Oakland Schools, Pontiac, Michigan.

"THE USE OF STUDENT RATIONALES IN DEVELOPING A MULTIPLE CHOICE TEST SOLUTIONS GUIDE"

Gerald Abegg
Newton College of The Sacred Heart
Newton, Massachusetts

For years specialists in testing and evaluation have argued that multiple-choice tests are most effective and reliable measures of student achievement if the foils provided for each question are logical wrong answers. These foils should reflect answers which a student could select as a result of faulty arithmetic, illogical reasoning, or misunderstanding of a concept. If the multiple choice test is designed with this concern in mind, the problem then focuses on providing a means of diagnosing student difficulties. For example, if a teacher found that half of his science class selected the same incorrect choice on a question, he should be able to identify the difficulty and correct it with appropriate remedial instruction.

In an effort to meet this demand for a diagnostic tool, the staff of the Physical Science II Project has developed a solutions guide for the PS II Achievement Tests based upon student rationales, in addition to test author or teacher rationales. When the tests are administered in pilot classes, each student is asked to state his reasons in writing for his answer on one assigned test question. These student rationales are compiled by questions and compared with the rationale written by the authors of the questions. Disagreements between student rationale and author rationale occur on about one-third of the questions. As a result of these disagreements the authors are able to identify specific student difficulties which are incorporated into the revision of the test and solutions guide.

The classroom teacher using the PS II multiple choice tests therefore obtains several kinds of information. The usual scoring and item analysis provides a range of scores and frequency of incorrect responses. In addition, the teacher is able to identify remedial instruction needed, by matching the item analysis to the solutions guide.

Although this paper will focus on the development of the PS II solutions guide, the presentation will be directed to the utilization of the technique by science educators who desire to expand the usefulness of their multiple choice tests.

DEVELOPMENT OF THE SCIENCE PROCESS SKILLS TEST (SPST)

Loretta L. Molitor
Towson State College
Towson, Maryland

It was the purpose of this investigation to develop an instrument to evaluate the skills of inference, prediction, and verification of children in grades four, five, and six. Skill definitions derived from descriptions of these activities in studies of thinking in the sciences led to specification of behavioral criteria for each skill. Test items were designed to conform to these specifications within a multiple choice format. Illustrations of objects and events assumed familiar to the students tested served as item stems and distractors.

A sample of ten items on each skill administered to small groups of fourth and sixth grade students indicated that these children understood the illustrations and test instructions. Items conforming to the established format were added to form a preliminary long form of the SPST consisting of seventeen items on each skill. These were submitted to a panel of three science educators. Those items unanimously judged as consistent with the stipulated definitions and performance criteria were retained for the revised long form of the test. Administration of this form to 60 urban and suburban sixth grade students served to establish testing procedures and eliminate items of unacceptable levels of difficulty and discrimination. The resulting final form of the SPST consisted of 26 items in three subtests: Inference, Prediction, and Verification. Sixty suburban students in grades four through six were interviewed on randomly selected test items. Association between item response and the student's reason for that response judged as consistent or not with the stipulated performance criteria was evaluated by an exact probability test.

A significant positive association for a majority of inference and verification items at all three grade levels indicated that these items were capable of illiciting stipulated performance. Few of the prediction items at any grade level displayed this capability. One aspect of construct validity of the SPST was demonstrated by significant differences in total test and subtest means resulting from group administration of the test to fourth grade children with four years of experience in Science: A Process Approach and a similar group without such experience. Group administrations of the test to 360 suburban fourth through sixth grade children resulted in relatively low reliability estimates (K-R 20). Item analysis procedures revealed that the inference subtest was easy for the group tested and that the prediction subtest lacked homogeneity. It was suggested that the low difficulty levels may reflect the inability of familiar item content to motivate skill behaviors. It was also suggested that prediction skill involves a

complex set of behaviors effected by the number of variables involved in a prediction task. It was concluded that the illustration format provides an easy to administer instrument capable of sustaining student interest. It was further concluded that the Science Process Skills Test provided a somewhat valid and reliable instrument to assess the inference and verification skills of upper elementary school children. Such an instrument can provide external criteria for evaluating outcomes of curricula designed to foster skill development.

THE DEVELOPMENT OF AN INSTRUMENT TO EVALUATE SIXTH AND NINTH GRADE STUDENTS' ATTITUDES TOWARD SCIENCE AND SCIENTISTS

La Moine L. Motz
Oakland Schools
Pontiac, Michigan

This study was designed to develop a valid and reliable science and scientists attitude instrument, and to determine the attitudes of sixth and ninth grade rural, urban and suburban students toward science and scientists. The attitude instrument was based upon a grid of key statements about science, and scientists. Part I of the instrument consisted of statements about science, Part II about scientists. Secondary, but contributing factors such as school geographic area, sex, grade, socio-economic backgrounds and intelligence quotients of the students were studied.

Ideas and statements about science and scientists were obtained by questioning 525 elementary, secondary and college students, plus scientists and science educators. The final form of the instrument resulted after extensive trial administrations for readability and understanding of the attitude statements. The instrument was validated by a jury panel of twenty professional scientists and science educators. The sample consisted of 981 male and female, sixth and ninth grade students from rural, urban and suburban communities.

Findings:

1. Reliability of Part I was .48; Part II was .78; reliability of the entire instrument was .78 for the sixth grade sample; .79 for the ninth grade sample.

2. Sixth grade suburban and ninth grade rural and suburban students scored significantly higher as to their attitudes toward science (Part I) than sixth grade rural and urban students. Ninth grade urban students, as a group, scored significantly lower than did ninth grade rural and suburban students, but significantly higher than either the rural or urban sixth grade students.

3. Overall, ninth grade students were significantly higher or showed a more positive attitude toward science and scientists than the sixth grade students when compared to the responses of the professional science and science educator control group.

4. Males and females were not significantly different from each other as to their attitudes toward science and scientists.

5. There was a statistically significant positive relationship between the socio-economic backgrounds of the students and their responses toward science and scientists. Students from higher socio-economic backgrounds showed a more positive attitude toward science and scientists as compared to agreement with a professional (science and science educator) control group.

6. There was a statistically significant positive relationship between the intelligence quotients of the students and their responses toward science and scientists. Students of higher intelligence quotients showed a more positive attitude toward science and scientists when compared to the professional control group.

Contrary to the opinions and beliefs of many science educators, a drop in the attitudes toward science and scientists was not apparent from the sixth grade to the ninth grade by the students in this study. Suburban students, as a group, at the sixth and ninth grade levels, possessed a more positive attitude toward science and scientists than the rural and urban groups. The study indicated that more attention should be given to the teaching or developing of attitudes of students toward science and scientists. Science education curriculum materials should be developed to include information about the development and practice of scientific attitudes.

Session IIb - Evaluation, Envoy Room

Chairman: Dudley Herron, Purdue University, West Lafayette, Indiana

1. "Evaluation of a Method for Teaching Hypothesis Formation to Sixth Grade Children," Mary Ellen Quinn, St. Mary-of-the-Woods College, St. Mary-of-the-Woods, Indiana.
2. "A Product Evaluation of Science - A Process Approach," Marvin F. Wideen, University of Saskatchewan, Regina, Canada.
3. "An Evaluation of a New Curriculum: Time, Space, and Matter," Harold Friend, Queens College, Flushing, New York.

EVALUATION OF A METHOD FOR TEACHING HYPOTHESIS FORMATION TO SIXTH GRADE CHILDREN

Mary Ellen Quinn
St. Mary-of-the-Woods
St. Mary-of-the-Woods, Indiana

The purpose of this investigation was to evaluate a method for teaching hypothesis formation to sixth grade children. In order to evaluate the method, a scale was developed to measure the quality of the hypotheses elicited during the study. That scale was developed by reviewing the philosophy of science literature to obtain a set of criteria for good scientific hypotheses. The criteria set, based largely on the philosophy of Poincare, Popper, Hanson, Caws, and Black, included: 1) it makes sense, 2) it is empirically based, 3) it is adequate, 4) it is precise, and 5) it states a test. Scores obtained using the Hypothesis Quality Scale constituted the criterion variable.

Four intact sixth grade classes in urban and suburban Philadelphia participated in the study. Treatment consisted of practice in hypothesis formation and instruction in how to distinguish good, fair, and poor hypotheses on the basis of the criteria for an acceptable hypothesis. Fifteen Inquiry Development Program film loops were used to elicit the hypotheses. The first three sets of hypotheses written by the control groups and the last three sets written by the experimental groups were scored in order to obtain the dependent variable. In each case, however, the same films were used to elicit the hypotheses; thus, there was a treatment and nontreatment group for each of the two different socio-economic levels.

Analysis of covariance, with scores on the Otis Quick-Scoring Mental Ability Test serving as covariable, was used to test the hypotheses of differences in the means of the following groups:

1. treatment and non-treatment
2. socio-economic level I and socio-economic level II
3. high and low intelligence scores
4. high and low overall grade point average
5. high and low reading ability
6. girls and boys
7. students with four or more siblings in the family and students with fewer than four siblings in the family

Hypothesis Eight (H_8) stated that individual students improve in their ability to hypothesize after instruction in hypothesis formation.

Hypotheses One and Four were accepted at the 0.001 level; Five was accepted at the 0.01 level; Three and Six were accepted at the 0.02 level; Seven was accepted at the 0.05 level; and Eight was accepted on the basis of the descriptive statistics used to judge it. Hypothesis Two was rejected.

Results of the investigation suggest the following conclusions:

1. Hypothesis formation can be taught.

2. The inquiry method of teaching used in this experiment can be used successfully to teach hypothesis formation to a class of fifty children.

3. The quality of the hypotheses elicited can be evaluated using the Hypothesis Quality Scale.

4. Urban children improve in the skill of hypothesizing as much as do suburban children who receive an equal amount of instruction in hypothesis formation.

5. The ability to formulate acceptable hypotheses is influenced by several factors. Among them are:

    a. intelligence as measured by the Otis Test

    b. overall grade point average

    c. reading ability

    d. sex

    e. number of siblings in the family

6. The number of siblings in the family has a different influence on the ability to learn hypothesis formation depending on the socio-economic level of the children.

A PRODUCT EVALUATION OF SCIENCE

A PROCESS APPROACH

Marvin F. Wideen
University of Saskatchewan
Regina, Canada

This study was designed to evaluate the program Science - A Process Approach. It was also intended that the results would permit some assessment of generally accepted notions of curriculum change. Three sets of hypotheses were proposed relative to the problem.

In the first group it was proposed that students pursuing the program Science - A Process Approach, when compared with those in a traditional program, would show a better understanding of science processes, have an improved attitude toward science, prefer science related activities to those in other subjects and have a more positive outlook toward their teacher and the classroom. It was also hypothesized that no differences would exist between the two groups in terms of science knowledge. Six measures were employed to test these hypotheses.

Secondly, it was hypothesized that teachers in the treatment group would show a better attitude toward science, more abstract belief systems and a better understanding of science processes when compared to those in the control group. Four measures were used to test these hypotheses.

The third group of hypotheses proposed that differences among students would not be related to student and teacher factors and teacher characteristics identified in the study.

Twenty-six teachers and 555 students from the Spearfish and Sturgis public schools were the subjects in the study. The measures were administered to the students at the beginning of September, 1970 prior to the treatment and again in April, 1971. Form A of the teacher measures was administered prior to the treatment for both groups, and in April of 1971, Form B of the measures was administered. During the treatment each teacher was taped on two occasions while teaching a science lesson. The treatment in the study involved the use of Science - A Process Approach and the accompanying inservice education provided for the teachers who taught the program in the Spearfish public schools.

Analysis of variance and covariance were used in factorial designs employing appropriate main effects to test the various hypotheses. Where possible, steps were taken to validate several of the instruments as part of the study.

The results of the study support the following conclusions:

1. SAPA had a consistent effect on student process skills related to the cognitive domain. Subjects in the experimental group did better and the effect was consistent for all students.

2. The treatment in the study was not effective in terms of generally increasing the interests of students in science related activities nor in causing them to perceive their classroom and teacher more positively. Indications were that the treatment was more effective for low achieving students than for high achievers.

3. Boys were more interested in science related tasks than girls.

4. The treatment in the study improved teacher understanding of science processes but had no effect on changing the teachers' verbal interaction or belief system.

5. An understanding of science processes on the part of teachers has an effect on the cognitive growth of students.

6. The results support the general notion that the program SAPA contributes to a fairly specific set of student outcomes.

AN EVALUATION OF A NEW CURRICULUM:

TIME, SPACE, AND MATTER

Harold Friend
Queens College, City University of New York
Flushing, New York

The primary purpose of the investigation was to determine whether the pupil-inquiry method of teaching Princeton University's Secondary School Science Project, Time, Space, and Matter, is superior to a teacher-directed method of teaching the same curriculum. In both cases, the teacher would be teaching for the objectives of critical thinking, an understanding of the methods of science (science as an activity by means of which one seeks to relate to the world), and a knowledge of specific subject matter content.

The sample for study in this investigation consisted of two "high" ability groups and two "average" ability groups. Both groups were selected from a population of six hundred eighth grade pupils in a Queens, New York City junior high school. The school was located in a middle socio-economic area in Flushing.

One of the two "high" ability groups was selected as a pupil-inquiry group by the flip of a coin, and one of the two "average" ability groups was chosen as a pupil-inquiry group by the clip of a coin. The final design had 25 "high" ability and 32 "average" ability pupils taught by the pupil-inquiry method, and an equal number of pupils taught by the teacher-directed method. The experiment lasted six months.

In order to determine whether differences existed in critical thinking ability, understanding of the methods of science, and learning of science facts and principles between eighth graders taught by the two methods, the Watson-Glaser Critical Thinking Appraisal, Form YM, the Test On Understanding Science, Form Jx, and a teacher-constructed Test of Science Facts and Principles were used.

The results of the study were based on analysis of variance difference scores from pre-test to post-test. Within the limitations of the experimental design, it was found that the pupil-inquiry method of teaching Time, Space and Matter was a more effective method of developing eighth grade pupils' understanding of the methods of science than the teacher-directed method. This was true whether the pupils were "bright" or "average."

It was also found that neither method was superior to the other in developing critical thinking ability or in the teaching of science facts and principles. This was true whether the pupils were "bright" or "average."

The results of this investigation have been interpreted as demonstrating that Time, Space, and Matter's pupil-inquiry method was an effective means of developing selected junior high school pupils' understanding of the methods of science, whether the pupils were "bright" or "average." This teaching method might be fruitful for other junior high school pupils of similar ability and experience.

Science education today needs new approaches and ideas. Time, Space, and Matter promises an efficient method of achieving some of the goals of science teaching through the use of its pupil-inquiry approach. There is also the implication from this study that other newly-developed curricula projects might promote such goals as an understanding of the methods of science.

Session IIc - "An Hour With" Session - Regency Room

Chairman: Paul Westmeyer, Florida State University, Tallahassee, Florida

"An Hour With Joe Novak About Learning"

Joseph D. Novak
Cornell University
Ithaca, New York

This seminar is designed to consider implications of Ausubel's learning theory for research in science education. The discussion, with accompanying slides and summary handouts, will be based upon a review of research drawing in large part upon the following papers:

Ring, Donald G., and Novak, Joseph D., "The Effects of Cognitive Structure Variables on Achievement in College Chemistry", Journal of Research in Science Teaching, 8:4: 325-333, 1971.

Novak, Joseph D., et al., "Interpretation of Research Findings in Terms of Ausubel's Theory and Implications for Science Education", Science Education, 55:4:483-526,1971.

Session IId - "An Hour With" Session - English Room

Chairman: Darrell Young, State University College, Buffalo, New York

"An Hour With Wayne Welch About Evaluation"

Wayne W. Welch
University of Minnesota
Minneapolis, Minnesota

This session is designed as an informal seminar to discuss problems related to the evaluation of science programs. Participants will be provided the opportunity to discuss problems they have encountered in designing and implementing their evaluation strategies. Dr. Welch will also be available to answer questions about several science evaluation studies he has conducted. These include: Harvard Project Physics, PSNS, Ginn Elementary Science Program, and the NSF Comprehensive Projects.

CONCURRENT SESSION III

Session IIIa - Evaluation, Ivy Room

Chairman: William C. Ritz, Syracuse University, Syracuse, New York

1. "A Description, Analysis, and Comparison of Evaluation of Chemistry Curricula Since the Inception of CHEM Study and CBA," Duane H. Dillman, Temple University, Philadelphia, Pennsylvania, and Michael P. Freedman, Northeast High School, Philadelphia, Pennsylvania.

2. "An Application of the Tucker-Messick Individual Difference Model to an Evaluation of the Objectives for a First-Year College Physics Course," Walter B. Boldt and Peter W. Hewson, University of British Columbia, Vancouver.

3. "Evaluation of an In-Service Elementary Science-Mathematics Project Based on Product Outcome Performance Objectives," John Nickel, Wichita State University, Wichita, Kansas.

A DESCRIPTION, ANALYSIS, AND COMPARISON OF EVALUATION OF CHEMISTRY CURRICULA SINCE THE INCEPTION OF CHEM STUDY AND CBA

Duane H. Dillman
Temple University
Philadelphia, Pennsylvania

and

Michael P. Freedman
Northeast High School
Philadelphia, Pennsylvania

The purpose of this study paper was to answer several important questions:

1. To what degree have CBA and CHEM Study been evaluated?

2. Are existing studies of CBA and CHEMS concentrating on original goals and objectives of the curricular projects or on other factors?

3. Do studies since 1964 support or contradict the tentative conclusions of one of the authors in an earlier study?

4. Is there evidence in the literature as to why CBA effect has been minimal?

5. What evidence exists today regarding the present and future needs in chemistry curriculum?

An exhaustive search of research and evaluation literature pertaining to CHEM Study and CBA was undertaken. In addition, contacts were made with the ERIC Center on Science and Mathematics Education and numerous science educators. This literature was classified, summarized, and analyzed for the present paper. Original objectives of CBA and CHEMS were documented and compared to research and evaluative data found since that time. The unpublished 1964 study by Dillman was compared to earlier and later studies to determine consistencies and adequacies of chemistry curriculum research and evaluation.

The significance and importance of this paper is in pointing out the inadequacy of the research and evaluation pertaining to CBA and CHEM Study since their inception, in suggesting changes for the present and future, and in emphasizing the need for more adequately attending to such questions within groups such as NARST.

AN APPLICATION OF THE TUCKER - MESSICK INDIVIDUAL DIFFERENCE MODEL TO AN EVALUATION OF THE OBJECTIVES FOR A FIRST-YEAR COLLEGE PHYSICS COURSE

Walter B. Boldt
and
Peter W. Hewson
University of British Columbia
Vancouver, British Columbia

The purpose of the investigation was to determine the structure of individual differences in viewpoints used by individuals in a group of judges selected to evaluate the objectives for a course in first-year college physics.

A group of 22 judges was selected to rate a set of 13 course objectives on each of a set of 14 bipolar adjectival scales. The judges were drawn from a number of academic disciplines -- physics, engineering, medicine, botany, zoology -- by the instructor on the basis of their concern about the objectives the instructor had set for the course prior to beginning instruction. The objectives were formulated by the instructor on the basis of the course rationale. The rating scales were derived from a consideration of the bases on which the instructor wanted the objectives judged. The ratings of the objectives were assembled into a judges X objectives X scales data matrix. Using the index of similarity suggested by Osgord and Suci as a measure of interpoint distance, the basic interobjective distance X judges matrix for the Tucker - Messick individual difference model was obtained. The distance measure was assumed to meet the ratio-scale properties required by the model.

Following the procedures stipulated by the Tucker - Messick model, an attempt was made to isolate, empirically, consistent individual viewpoints about the course objectives among the judges. The dimensions of the structure of individual differences obtained by this procedure summarize consistencies in judgments of the objectives and, as such, represent consistent individual viewpoints of the objectives.

Multidimensional scaling procedures were subsequently applied to the results of the viewpoints analysis in order to determine the judgmental structures corresponding to the consistent viewpoints isolated.

Finally an attempt was made to account for the different ways in which the objectives were differentiated, as represented by the dimensions of the judgmental structures obtained, in terms of the factors (bases of judgment) underlying the rating scales.

Application of the Tucker - Messick individual difference model to the data yielded two consistent viewpoints among the 22 judges. One viewpoint was predominantly held by judges in the physical sciences (physics, engineering) and the other by judges in

the life sciences (botany, medicine, zoology). The structures of the two viewpoints differed in terms of complexity or dimensionality. Judges in the physical science group tended to differentiate between the objectives in two different ways while the judges in the life sciences essentially used a single dimension for judging the objectives.

The objectives singled out in both viewpoints had to do with students wanting to be involved in deciding what should be taught in the course, students wanting to be involved in deciding how the course should be taught, and students using their grades in the course as a guide for making decisions about a future career. The first two goals appeared to be singled out from the others because they were considered unimportant by the physical science group. The same group singled out the third objective on the basis of difficulty of attainment. The life science group differentiated between the third objective and all the rest on the basis of its lack of importance.

The investigation was undertaken in response to a problem of classroom practice -- deciding the merit or worth of a set of educational goals for a course. Evaluating objectives is a complex task because it involves judgments of merit based on different points of view. Determining the nature of the viewpoints taken by judges in evaluating the objectives is seen as valuable information to the instructor, because it enables him to set priorities on a more rational basis. The present study is an attempt to extend the applicability of a fairly recent psychometric technique for meeting problems of classroom practice.

The research also has an important theoretical aspect to it in that an easily obtained index of interpoint distance was used which was assumed to meet the rather restrictive scaling properities required by the model. Although there is some evidence to warrant this assumption under certain conditions, there was no guarantee that the measure was appropriate in the present case. As it turned out, useful results were obtained. Further investigation, however, should be carried out to determine to what extent the results of the present study would have been different had the assumptions of the model been rigorously adhered to.

EVALUATION OF AN IN-SERVICE ELEMENTARY SCIENCE-MATHEMATICS PROJECT BASED ON PRODUCT OUTCOME PERFORMANCE OBJECTIVES

John Nickel
Wichita State University
Wichita, Kansas

The evaluation research effort herein described was aimed at determining the efficacy of an in-service teacher education project for elementary teachers. The teachers were trained over a three year period to teach Science and Mathematics as one subject to elementary school students in an area encompassing sixteen school districts in South-Central Kansas.

The evaluation covered four general areas: (1) Teacher Attitude, (2) Student Perception of Teaching Practices, (3) Student Attitude, and (4) Student Achievement. To assess these four general areas a series of product outcome performance objectives were prepared for each general area. Ninety-one performance objectives were included in the analysis.

Pre-established criterion levels for each performance objective were established and how the objective was measured is presented.

TABLE 1

SUMMARY OF STUDENT RESULTS BY GRADE

	Grade	Opinion	Attitude	Achievement
No. of Objectives			3	2
No. of Objectives Met	1-2		3	1
No. of Objectives		10	3	2
No. of Objectives Met	3	8	3	1
No. of Objectives		10	3	4
No. of Objectives Met	4	7	3	3
No. of Objectives		10	3	3
No. of Objectives Met	5	6	2	1
No. of Objectives		10	3	3
No. of Objectives Met	6	7	3	0
No. of Objectives		10	3	6
No. of Objectives Met	7-8	7	2	5

TABLE 2

SUMMARY OF TOTAL RESULTS

	Student			Teacher
	Opinion	Attitude	Achievement	Attitude
No. of Objectives	50	18	20	3
No. of Objectives Met	35	16	11	3
% of Objectives Met	70	89	55	100

The results by grade are presented in Table 1 and the results for total are summarized in Table 2.

An examination of Table 1 indicates that the results associated with primary grades were more consistent with the criterion levels of the objectives. Through grade four, approximately three-fourths of the objectives were met. The results associated with grades five and six were, relatively, the lowest. The results associated with grades seven and eight were more consistent with results associated with grades one through four.

In total, there were 91 product outcome objectives, of the 91 objectives, the criterion was reached in 65 or 71% of the objectives.

The model of evaluation represented here is exemplary in that evaluation is based, in the main, on pre-established criterion levels of product oriented behavioral performance. The criterion level was set so a clear majority of students would be performing in a direction consistent with project recommendations, or as reflecting a positive student response.

This approach allows the project personnel to evaluate performance of students, teachers and project staff so that modification and improvement of the goals of the project can be implemented.

Session IIIb - Learning Theory, Envoy Room

Chairman: Richard Reis, Memorial University of Newfoundland, St. John's, Newfoundland, Canada

1. "A Comparison of Two Methods of Instruction in College Science," Morton L. Wolfson, City University of New York, New York City, New York.

2. "The Identification and Significance of Intuitive and Analytic Program Solving Approaches Among College Physics Students," Martin N. Thorsland, Brown University, Providence, Rhode Island, and Joseph D. Novak, Cornell University, Ithaca, New York.

3. "Systems Approach Applied to the Cognitive Domain," Daniel J. Dyman and Jerry J. Nisbet, Ball State University, Muncie, Indiana.

A COMPARISON OF TWO METHODS OF INSTRUCTION IN COLLEGE SCIENCE

Morton L. Wolfson
City University of New York
New York City, New York

Low enrollments in the physical science courses and the seeming rejection of science courses by non-science majors in college has been a matter of concern to science department staffs for a long time. The purpose of this paper is to present an alternative proposal designed to stimulate interest while encouraging independent research.

Three classes in College Science, a two-semester course required of all non-science majors at John Jay College, C.U.N.Y., averaging 30 students per class, were divided randomly into two groups. The first group, hereafter called the "formal" group, was required to attend lectures, take regular examinations (3 per semester) and a final examination at the end of the semester. Their final grade was based on lab reports and examinations. The second group, hereafter called the "informal" group,was permitted to select a research topic, (a list of 15 was given them, but they had the choice of changing any one or submitting their own that was not on the list) and use it as a guide for their work for the semester. They were required to appear at the beginning at each class (for attendance purposes) and were then free to remain or leave if they needed to work at the library or elsewhere, on their project. On lab days, they remained to participate in the lab activity. At regular intervals they were required to turn in outlines, bibliography and progress reports; the final paper being due two weeks before the end of the semester, with an oral presentation (10 minutes before the whole class) also required. Final grade was given on the basis of the material submitted during the semester, lab reports, final paper, and talk.

Pre- and post-tests (objective type) were given to both groups, including a retest 4 weeks after the end of the semester, (this was possible since students remain in the class for the full year). Questionnaires were given out at the beginning and end of the semester to elicit comments on attitudes toward science, science courses and science teaching. Results showed a significantly greater increase in knowledge for the formal over the informal, however that difference was lost by the time of the retest 4 weeks later. What was more apparent and striking was the result of the attitude test, which showed the informal with a much higher opinion of science, etc., indicating good reason for this study to be replicated and carried further.

THE IDENTIFICATION AND SIGNIFICANCE OF INTUITIVE AND ANALYTIC PROGRAM SOLVING APPROACHES AMONG COLLEGE PHYSICS STUDENTS

Martin N. Thorsland
Brown University
Providence, Rhode Island

and

Joseph D. Novak
Cornell University
Ithaca, New York

A multitude of recent efforts have focused on individualizing science instruction in an attempt to be more responsive to the individuals' needs. Reported research has been concerned with the identification of global, non-content-specific individual differences with little or no attempt at relating these differences to any learning theory. No research found investigated specific identifiable differences within one subject matter area and their relationship to relevant learning related parameters. In courses such as physics, problem solving is considered to be basic for developing an understanding of necessary concepts and ideas. A knowledge of the role of problem solving abilities in the learning process would thus seem of paramount importance. This study attempted to determine the existence and significance of differences in problem solving approach in college physics students using a theoretical framework derived from the ideas of David P. Ausubel.

A sample of twenty-five physics students receiving instruction via audio-tutorial methods were presented several physics problems in an interview situation. The taped interviews were analyzed and ratings were assigned indicating students' intuitive (I) and analytic (A) problem solving tendencies. The analytic approach was characterized by step-by-step analysis, explicit in nature, most often utilizing mathematical equations and symbols. The intuitive approach was characterized by an implicit "feel" of the subject matter with little or no awareness of steps used.

Four groups of students were established corresponding to extreme ratings on the intuitive and analytic dimensions - e.g. low I- Low A, low I- high A, High I- low A, and high I- high A. The groups were compared on various learning related parameters such as SAT scores, background and preparation, achievement, time spent in learning and learning efficiency (defined as achievement divided by associated learning time).

The findings and conclusions of the study were as follows:

1. It was possible to establish consistent and reliable ratings of students' intuitive and analytic problem solving tendencies.

2. The analytic dimension was significantly related to scholastic aptitude while the intuitive dimension was not. These two abilities appear to be separate and distinct and not two extremes of a continuum.

3. The highly analytic individual (a) achieved at a higher level, (b) spent more time in learning, and, (c) was about as efficient in learning when compared to the low analytic individual.

4. There was a suggestion that the intuitive dimension was related to the availability of major concepts relevant to the study of physics.

5. The highly intuitive individual (a) achieved at a higher level, (b) spent less time in learning, (c) was somewhat more efficient in learning, and, (d) made more references to concrete experience when compared to the low intuitive individual.

6. There was evidence to suggest a facilitating effect of a highly differentiated cognitive structure on new learning. The learning efficiency steadily increased in the high I- high A group, but this was not as pronounced in the other groups.

7. There was a significant interaction between the intuitive and analytic dimensions on learning time and learning efficiency.

These results point toward the desirability of gearing instructional regimes to specific individual differences, i.e., individualization of instruction. This research represents only one small step in a continuing effort at defining learning and its concomitants in an attempt to better understand the learning process.

SYSTEMS APPROACH APPLIED TO THE COGNITIVE DOMAIN

Daniel J. Dyman
and
Jerry J. Nisbet
Ball State University
Muncie, Indiana

The demand for relevance and attention to teaching strategies are among today's critical issues in higher education. Subject matter should be related to the practical and intellectual concerns of the student and technological aids for individualized instruction should be more fully explored.

Accepting these premises for the improvement of education presents the problems of: (1) developing instructional materials with content areas organized to include relevant topics; (2) designing a systems approach to individualized instruction which incorporates expedient technological resources; and (3) testing the instructional materials to determine if preconceived objectives were achieved.

The general studies biology course at Ball State University was selected as an ideal setting for conducting this research because the course accommodates large numbers of students with an array of background and interest characteristics.

The criterion, student interest, guided the selection of Birth, Birth Control, and Genetic Counseling as topics for developing relevant prototype instructional materials. Student behavioral objectives were formulated and instructional systems were built upon strategies which attempted to select the most appropriate teaching media to attain the designated outcomes.

Audio-tutorial instruction was the basic mode into which systems for individualized instruction and technological resources were implemented. Programmed instruction was utilized to treat involved concepts such as the effects of the Pill on the menstrual cycle. Experiments such as the influence of drugs on chick embryo circulation were designed to involve students in guided discovery. Directed observations of a variety of specially designed visuals including a film clip of vertebrate sexual reproduction, a working model of fetal osmosis, and a 35 mm slide series on removing chick embryos were implemented to teach facts, concepts, principles, and techniques. Readings of case histories such as "What Doctors Now Know About Your Unborn Baby" were incorporated to stimulate interest. And, a Learning Guide was designed to direct student interactions with the instructional system, recording observations and responding to problem situations.

A pilot study of the prototype materials was conducted with six volunteer students. Test results and feedback from the pilot study group were analyzed and, where necessary, new strategies were incorporated to enhance the effectiveness of the instructional systems. After being introduced into the regular general studies biology format, analysis of student feedback, questionnaire appraisal, and comprehensive testing of over 600 students led to the final revision of instructional strategies.

Questionnaire appraisal of the finalized prototype instructional systems indicated that a decisive majority of students reported the instructional systems to be relevant, current, and interesting. Test data analysis indicated that the students achieved beyond the minimum established criteria for the success of the prototype instructional systems. Furthermore, test data indicated that the selection of instructional strategies were effective means for the attainment of the respective student behavioral objectives.

The study has provided a basis for the development of effective large group instructional materials which are relevant and meaningful to the general studies biology student and a starting point for research whereby each component in the instructional strategies can be tested for its particular contribution to the instructional system.

Session IIIc - "An Hour With" Session - English Room

Chairman: H. Craig Sipe, State University of New York at Albany

"An Hour With Henry Walbesser About Research Design"

Henry Walbesser
University of Maryland
College Park, Maryland

This discussion of research design draws upon all volumes of the Journal for Research in Science Teaching as the data source. Three classification analysis systems are applied to this literature collection. The first system concerns cataloging according to descriptions such as exposition or research; historical, philosophical, descriptive, or experimental; and the presence or absence of a test of significance.

The second classification-analysis system focuses upon relationship between design and threats to internal and external validity. This error analysis reflects standards suggested by R. A. Fisher in The Design of Experiments, Donald T. Campbell and Julian C. Stanley in Experimental and Quasi-Experimental Design for Research and James Raths in Studying Research.

The third classification-analysis system concerns the estimation of power as described by Jacob Cohen in Statistical Power Analysis for the Behavioral Sciences as well as Amos Tversky and Daniel Kahnman in "Belief in the Law of Small Numbers". Each experimental study with a test of significance is analyzed in terms of power. Rationale for such consideration is also explored.

Finally, recommendations for science education research in general, and future volumes of J.R.S.T. in particular, are proposed based upon the findings of the three analyses.

Session IIId - "An Hour With" Session - Regency Room

Chairman: Paul E. Bell, Pennsylvania State University, University Park

"An Hour With Paul Hurd About New Directions In Science Education"

Paul Hurd
Stanford University
Stanford, California

This seminar is designed to be a question and answer session intended to explore problems and issues influencing science teaching at the present and which are likely to affect future years. A basic assumption underlying the discussion is that science education is at a turning point and we need to take a close look at new directions.

CONCURRENT SESSION IV

Session IVa - Evaluation, Ivy Room

Chairman: Robert Collagen, Morgan State College, Baltimore, Maryland

1. "A Comparative Study of a Research-Oriented High School Advanced Biology Class and a Conventional Textbook-Centered Class," Alva N. Smith, and H. Seymour Fowler, Pennsylvania State University, University Park, Pennsylvania.
2. "A Study of the Effect of Timed Pupil Feedback on the Teaching Behaviors of Biological Science Teachers," John H. Novak, and Gene W. Moser, University of Pittsburgh, Pittsburgh, Pennsylvania.
3. "Instructional Efficiency with Biological Objects in a Task Requiring Dichotomous Keying Techniques," Carl E. Funk, Jr., and H. Seymour Fowler, Pennsylvania State University, University Park, Pennsylvania.

A COMPARATIVE STUDY OF A RESEARCH-ORIENTED HIGH SCHOOL ADVANCED BIOLOGY CLASS AND A CONVENTIONAL TEXTBOOK-CENTERED CLASS

Alva N. Smith
Pennsylvania State University
University Park, Pennsylvania

and

H. Seymour Fowler
Pennsylvania State University
University Park, Pennsylvania

The study attempted to supply some sound evidence as to which of two specific instructional methods, namely research-oriented or conventional textbook-centered, results in higher achievement in biology, more positive attitudes toward science and scientists and scientific careers, and the development of greater critical thinking skills in students.

An investigation of randomly selected schools teaching a research-oriented and conventional textbook-centered advanced biology courses was conducted during the school year 1969-1970. The research-oriented classes were designated the treatment classes and the conventional textbook-centered classes were designated the control classes.

As controls, pre-test measurements were conducted in three areas, achievement in biology, science attitudes and critical thinking ability. Student ability was also measured by use of the Scholastic Aptitude Test total scores. Students were additionally evaluated relative to the factors of sex and socio-economic status.

The post-test versions of the Nelson Biology Test, Allison Adaptation of the "Allen Attitude Scale" and the Watson-Glaser Critical Thinking Appraisal were administered as criterion measures for use in comparison and testing of the null hypotheses. The factors of sex and socio-economic status were examined relative to achievement on the criterion measures for both instructional methods.

The comparison of the treatment and control groups by means of a one-way analysis of covariance revealed no significant differences on two of the three criterion measures. Achievement in biology as measured by the Nelson Biology Test revealed a significant difference at the .01 level in favor of the control group.

A two-way analysis of covariance combined with a regression analysis indicated no significant differences between the treatment and control groups concerning the factors of sex and socio-economic status relative to achievement on the criterion measures.

The results of this study have indicated that the two methods of instruction when compared on the criterion measures chosen were essentially equivalent. The results of this study should be helpful to other investigators and to school systems that are considering the implementation of an advanced biology course. For example, additional information is now available via this study to school administrators relative to the selection of one or the other method of instruction for classroom use.

Through this study the relative effectiveness of a new method of teaching an advanced biology course was explored. Professional educators must continue t search for better ways to teach science in the secondary schools. his investigation suggests the desirability of extending research opportunities for high school advanced biology students as indicated by the relative equivalency on the criterion measures of both instructional methods.

A STUDY OF THE EFFECT OF TIMED PUPIL FEEDBACK ON THE TEACHING BEHAVIORS OF BIOLOGICAL SCIENCE TEACHERS

John Novak
University of Pittsburgh
Pittsburgh, Pennsylvania

and

Gene W. Moser
University of Pittsburgh
Pittsburgh, Pennsylvania

The purpose of the study was to investigate what effects timed hard-copy feedback, recorded by students during a lesson, would have on teacher behavior.

A pilot study was first conducted during February of the 1970-71 school year. Two hundred ninety two high school biology pupils were asked the following question: "What types of comments would you like to feedback to a teacher during a lesson in order to help the teacher teach you?". Responses were categorized and made into a student response sheet. The form was then used by three teachers in March, 1971, to test the feasibility of its use in a study to take place the following school year. Feedback from the students and teachers participating in the pilot study showed the following: (1) the students took the device seriously, (2) the students did not think completing the sheet during a lesson was distracting, (3) there was a consistency of remarks made by individuals at any one time interval during a class, (4) the participating teachers did not find it distracting, (5) teacher reaction was highly favorable.

On the basis of the pilot data, the following study was done during the 1971-72 school year. Ten different tenth grade high school biological science teachers participated during the first month. An experimental class was chosen for each teacher participating and audio-tapes were taken twice a week at random intervals of this class period. During the second month of the study, the teachers used the timed student reaction sheet and audio-tapes were again made of the experimental classes in the same manner as before. The third month of the study was again audio-taped as before, but the student reaction form was not used.

Three audio-tapes from each month were chosen at random and analyzed by using a Modified-Parakh's Interaction Category Analysis System and a Gallagher-Aschner Questioning Categories System. The data was further analyzed using Moser's Six Set Theory in order to describe the teaching mode in which each teacher was during each of the three months. During the fourth month, five new teachers went through the same three-month process as teachers in the first three months and in the seventh month a third group of five different teachers went through the same procedures as the first two groups.

Data seem to support the hypothesis that students can be used in effecting change in teacher behavior and that these changes can be described in a systematic and meaningful way. Data results also point to the use of high school pupils as a source of aid in the training of future teachers of science. The teacher's own pupils were found to help him to learn to interact with and respond to the dynamics of a classroom.

INSTRUCTIONAL EFFICIENCY WITH BIOLOGICAL OBJECTS IN A TASK REQUIRING DICHOTOMOUS KEYING TECHNIQUES

Carl E. Funk, Jr.
and
H. Seymour Fowler
Pennsylvania State University
University Park, Pennsylvania

The purpose of this study was to investigate the communication and problem-solving abilities (efficiencies) of an instructional strategy upon a specified medium of instruction in several tutor-learner dyads as well as to gather evidence to either substantiate or discredit the Snyder proto-theory of tutor-learner efficiency.

Criterion performance for the experimental task was to separate a group of eight leaves into two subgroups of four each on the basis of one (or more) stimulus dimension(s) and each subgroup was subsequently divided twice more to form the single units. The problem, therefore, was described as a three-stage problem for the subject.

A pilot study of the project was run with fifth graders from central Pennsylvania schools. The students (thirty-one) were asked to complete the presented task. All solutions of the task were recorded and analyzed by the dynamic programming operation to find the "optimal" and the "least-optimal" path solutions to criterion. The optimal path was defined as that solution which required the fewest number of transactions for these students within the dyads to complete the task successfully. The path that required the greatest number of transactions for the student was called the least-optimal strategy. Transactions were classified as either tutor-initiated or learner-initiated but in either case were always terminated with a tutor's response.

One hundred and twenty students were used for the actual study. The general procedures of the pilot study were followed in the study. The task, itself, however, was different. In this case the students were presented with either the optimal or least-optimal path as found by the students in the pilot study. The students were shown the leaves already separated into the two subgroups of four and were instructed to give a rule that they thought common to all leaves in one subgroup and yet in some way was different from the leaves in the other smaller group. The group of four was subsequently divided twice more until all the leaves were in the eight mutually exclusive classes as defined by the students in the pilot study. Criterion, in this case, was defined as the student's identifying the "correct" trait(s) that was congruous to the trait selected by the subjects in the pilot study.

Dynamic programming was used to determine the optimal and least-optimal paths to solution. The possible enumeration of every possible path solution for the task is not so efficient as the dynamic programming technique due to the calculable return function associated with dynamic programming.

The experimental task was considered to be a criterion-referenced task rather than a norm-referenced task as the students were compared with their performance against the task and not compared with each other. A measure of communication efficiency for the two strategies was calculated by comparing the mean number of transactions needed by the subjects to complete the task.

On the basis of a Behrens-Fisher $\underline{t}'$ test comparing the measures of communication efficiency for the two strategies, the following conclusion was reached: Dyadic efficiency was better realized with the optimal strategy than with the least-optimal. This means that for this experimental task the subjects performed significantly better with the optimal path presentation than with the least-optimal path. On the basis of an F_{max} test comparing the variances of the two treatment groups, it was concluded that the subjects using the least-optimal path exhibited more variability in verbal interaction with the tutor than those subjects using the optimal path solution.

Session IVb - Learning Theory, Envoy Room

Chairman: Maureen Dietz, University of Maryland, College Park, Maryland

1. "Information Processing at the Memoryful and Memoryless Levels in Problem-Solving and Recall Tasks," Frank Fazio, and Gene W. Moser, University of Pittsburgh, Pittsburgh, Pennsylvania.

2. "Information Processed by Negroid and Caucasian Children Engaged in Problem Solving Tasks," Barbara Felen, and Gene W. Moser, University of Pittsburgh, Pittsburgh, Pennsylvania.

3. "An Information Theoretic Model for the Human Processing of Cognitive Tasks," Gene W. Moser, University of Pittsburgh, Pittsburgh, Pennsylvania.

INFORMATION PROCESSING AT THE MEMORYFUL AND MEMORYLESS LEVELS IN PROBLEM-SOLVING AND RECALL TASKS

Frank Fazio

and

Gene W. Moser
University of Pittsburgh
Pittsburgh, Pennsylvania

Humans probably differ in the means by which they process information. The differences may be due to a cognitive style or it may be the manner in which they use the long term memory store. Another important factor may be the amount of time since reviewing information. There have been many experiments involving recall and the time-decay of knowledge. However, no study has ever involved an information theoretic treatment of processing information procured by humans in recall and problem-solving cognitive tasks. The purpose of the study was to measure and interpret the flow of information in two cognitive tasks.

Two samples of humans were studied. One was of 13 graduate students, aged 21 to 51 years, who took the Hunt Test of Conceptual Level. Then they participated in the chain flow of information experiment. This involved a six minute monologue heard by subjects selected on the basis of information values obtained in the Hunt Test. These subjects then verbalized the informational content to other human receivers, who in turn generated that content to another human. Chains of four to six human receiver-transmitters were conducted in this manner. Time decay of external information flow was controlled by some of the initial human receivers waiting for 30 to 36 minutes before starting a chain flow of information.

The second sample of adult humans participated in the chain flow experiment. However, they repeated the recall phase one week later when they constructed a written statement by randomly drawing term messages which had been in the initial content.

Verbal and written statements were analyzed for the terms output from the original source and transmitted through chains of information flow. Nine information theoretic measures were determined for each subject. The same measures were used to interpret the uncertainty of terms flowing through each transmission chain.

The statistical tests for significant differences used in the analysis included correlational analysis, analysis of regression, basic data relation matrix tests for time increments, and the Fisher Z-Test.

The humans processed one to one and one-half bits of long term memory information in solving problems and in recall tasks. There was considerable evidence that some humans restructured the term content in recall tasks, yet differed in strategies used in problem solving tasks.

It was found that input information, the information retrieved from long term memory stores, and in equivocation interact in the processing of the two tasks. There were significant correlations found for the same humans processing both LTM information tasks at the memoryless level but not for the memoryful conditions. Channel capacity was found to differ in both tasks. Again, the input information was significantly related to equivocation when problem solving was processed at the memoryful level. However, there was no significant relationship at that level in memoryful recalling of information. Both tasks were processed at the memoryless level with a significant relationship found between input and equivocation information.

Threshold channel correction limits were calculated for both tasks in both memory conditions. The limits were the lower bound at which there was a threshold of error-correcting information, or the level at which channels became noisy. It was found that LTM information did not have a significant role in either task. However, the limits were controlled differently as a function of the amount of input information. In recall tasks the humans had a tolerance range permitting a 59.7% decrease of input information. However, the same humans, when doing problem solving tasks, actually allowed a 47.6% increase of input information before noisy channels ensued.

The major educational value of this study is that it identified the ways in which individual humans processed information while conducting two kinds of tasks. Further research can enable us to identify patterns of memory processing of information in the conduct of learning experiences.

INFORMATION PROCESSED BY NEGROID AND CAUCASIAN CHILDREN ENGAGED IN PROBLEM SOLVING TASKS

Barbara Felen

and

Gene W. Moser
University of Pittsburgh
Pittsburgh, Pennsylvania

The purpose of this particular study was to describe an information theoretic model that could provide quantitative measures of degrees of information processing that occur as various cultural groups engaged in problem-solving behavior. More specifically, it explored the potential of such a model in the analysis of the overt responses of Negro and Caucasian students in grades two and eight as these students physically manipulate an electric circuit problem.

The sample was drawn from a population of second and eighth grade students enrolled in a suburban public school district in North Carolina. Each grade level was represented by 30 Negro and 30 Caucasian subjects chosen from middle income range families. These subjects were expected to physically manipulate an electric circuit problem. That is, given one one and one-half volt dry cell, one single throw switch, two miniature light receptacles (with bulbs) and five wires with alligator clips at each end, students were told to put the materials together so that both bulbs would light and so that when both bulbs were lit one could be unscrewed while the other still remained lit. The various connections made by each student were recorded in sequence on eight by eight matrices. Data were classified into four categories, matrices processed by successful Negro and Caucasian students and matrices processed by unsuccessful Negro and Caucasian students. These matrix categories were established for each grade level and information measures were calculated from them.

Correlational and regression analyses were used to test significant differences between information measures obtained by grade levels, sex, and race samples.

It was possible to compare and contrast actual information, maximum information, conditional information, relative uncertainty, redundancy, channel capacity, equivocation and real information measures for the various cultural groups. Relationships were found between such factors as race, number of connections made, age and problem-solving outcome. The major differences in information processing involved noise information rates and management, error correction, and redundancy. Significant relationships were found in the manner by which races operate error-limiting channel capacities in original and steady states of dependence. Thus the study provided answers to questions of the following type:

(1) At what rate do the various cultural groups process information?

(2) Do successful problem-solvers of various cultural groups differ both from unsuccessful problem-solvers of their same cultural group and from successful problem-solvers of another cultural group in their mode of information processing?

It appears that the greatest educational implication of this study lies in the fact that by enabling us to quantitatively describe an information processing environment of a cultural group we may, in turn, be better able to develop environments that are beneficial to this information processing.

AN INFORMATION THEORETIC MODEL FOR THE HUMAN PROCESSING OF COGNITIVE TASKS

Gene Moser
University of Pittsburgh
Pittsburgh, Pennsylvania

Cognitive tasks done by humans involve the processing of information, and this relates the human memory to the external environment. This processing of information has never been described with a complete Information Theoretic model. The purpose of the analysis was to construct and test a model for information processing in cognitive tasks. The criterion tests were to distinguish the amounts of information flowing in different cognitive tasks, and which were processed by humans possessing particular properties.

Seven studies were conducted to test the model and its' components. These studies were of humans ranging in ages of six to fifty-one years. They engaged in processing tasks in classroom and non-classroom environments. The tasks were of abstract and concrete types, and included recognition, recall, and problem solving. Verbal and non-verbal behaviors were conducted by the subjects. The behaviors were recorded and classified using a modified Parakh Interaction Category System, term analysis, the Kondo Question Category System, through item recognition listings of perceived objects, and matrix recording of non-verbal manipulations of concrete objects. In several instances, these data were tested against external data secured through psychological tests or interpreted by a Piagetian analysis technique.

The behavior actions were quantified as to frequencies and were converted to probabilities. Information Theoretic measures were then determined by the use of matrix transition probabilities. Data from each study were given a test for being Markovian. Nine information theoretic measures were thus obtained for each set of data. The measures were actual information, conditional information, code or transinformation, output or independent information, equivocation, shared information, real information, long term memory information, and noise. Some of these measures were derived by the researcher and were tested for relatedness to existing measures.

The Markovian matrices of data were raised in powers until they reached steady state where a memoryless condition was obtained. This procedure permitted comparing memoryful or dependent behaviors in tasks with those with memoryless meanings. Degrees of change in dependence were analyzed for phase spaces and patterns relevant to types of cognitive tasks.

The nine information theoretic measures for the memoryful and the memoryless conditions were tested for significant differences by using correlational and regression analysis, the Fisher Z-Test, and a modified Darwin Chi Square Test.

The memory model was found to be significantly meaningful in describing the human information processing of cognitive tasks. Chains of behaviors were Markovian and time-decay dependent. Comparisons of memoryful and memoryless conditions of information flow enabled an isolation of several memory processes described by Sternberg and Atkinson. Evidence of learning information processing was also isolated through analyses of memoryless behavior.

Humans differ in the use of and the kind of information processed in their executing different cognitive tasks. Studies employing the humans revealed this and that the differences were due to interactions between input information, equivocation, coding, and LTM (long term memory isolated at the memoryless level). Problem solving or desired-stated-of-affair tasks involved a controlling and balancing of the noise in the input and output information in transmission channels. In classroom recognition tasks of a dialogue kind, the noise control was not significantly balanced and the flow of useful information was a function of the attending behavior of the humans; with inverse and direct ratio equations of the feedback form distinguishing the channel capacities. Recall task processing was found to differ from problem solving by an inverse management of noise control; as conditions shifted from the memoryful to memoryless levels.

A major finding was the first significant demonstration of C. Shannon's theorem (Bell System Technical Journal, July and October, 1948) on error capacity of communication channels. He postulated the minimum error of input into a channel would be limited to a correction factor, H_y (X), at a slope of one. It was found that a slope of 1.03 zero error capacity typifies the informational content input for verbal dialogues.

The proposed memory model has been tested in a total of 11 experiments. Each time it has been found significant in quantifying information processes. Its' efficacy is that it has universal applications for describing human behavior, and may be a revolutionary means for interpreting when and how learning occurs in educational environments.

Session IVc - Verbal Behavior, Regency Room

Chairman: Michael Szabo, Pennsylvania State University, University Park, Pennsylvania

1. "The Relationship of Attitudes, Knowledge, and Processes to Initial Teaching Behaviors in Science," Ryda D. Rose, University of Pennsylvania, Philadelphia, Pennsylvania.

2. "A Study of Relationships Among Verbal Interaction, Student Achievement, and Attitude in Selected Two and Four Year College General Chemistry Classes," Mary Clare Cangami, New York University, New York City, New York.

3. "The Effect of Interaction Analysis Training and Feedback on Aspects of Science Teacher Classroom Intentions, Perceptions and Behaviors," Kathryn Beam, State University College, Buffalo, New York.

THE RELATIONSHIP OF ATTITUDES, KNOWLEDGE, AND PROCESSES TO INITIAL TEACHING BEHAVIORS IN SCIENCE

Ryda D. Rose
University of Pennsylvania
Philadelphia, Pennsylvania

Research has indicated a relationship between the science knowledge possessed by a teacher and the methods he uses in teaching. Little or no attempts have been made to show any relationship between the science attitudes of a teacher and his ability to use the science processes with his classroom performance. This study attempted to assess scientific attitudes as well as knowledge of science content and processes and their relationship to initial teaching behaviors of preservice elementary school teachers teaching science. The inclusion of two groups of such student-teachers attending a liberal arts college permitted the descriptive aspect of the study to be extended into an experimental design. One group of subjects was subjected to a treatment of a methods course in teaching science in the elementary school which emphasized positive attitudes and process knowledge. Thus, changes in the three above independent variables (content, attitude, and processes) were analyzed as well as their relationships to ten specific teaching behaviors, the dependent variable.

Thirteen subjects taking the science methods course were given five pretest measures: the Nature of Science Scale (NOSS) and the Science Support Scale (TRI-S) to assess scientific attitudes; the STEP science test for science content; and the Science Process Instrument (SPI) and the AAAS Teachers' Process Measure for process knowledge. The group was dichotomized at the median score, and high and low sub-groups were analyzed with regard to tend teaching behaviors in three types of classroom situations: tutorial, microteaching, and an intact class. A concurrent control group of twelve subjects was measured similarly and observed teaching in a tutorial and microteaching experience. All teaching sessions were observed, audiotaped, and analyzed by the investigator using the University of Pennsylvania Interaction Analysis System (UPIAS), a thirty-category interaction analysis measure recording affective, cognitive, and physical classroom dimensions. Equivalent post-tests were given the experimental group after the treatment.

Eighteen hypotheses were tested concerning the relationships of attitudes and knowledge of content and process to (1) teaching behaviors in the different teaching situations, (2) mean teaching behaviors in a sequence of observed lessons, (3) the variety of science concept-areas chosen, (4) significant differences between the investigated groups as a function of time and the intervening treatment, and (5) the interaction effects among the variables and teaching behaviors. The results of the study indicate that microteaching situations encouraged more manipulative activity, more pupil-talk, more pupil-initiated response, and higher level inquiry patterns of teaching behavior, while in the tutorial there was significantly more

teacher-talk. A preservice elementary school teacher's knowledge of the processes of science had precedence over knowledge of content and attitudes with regard to initial teaching behaviors in the following related to questioning behavior: (1) higher level questions, (2) teacher-question-response to pupil-initiated comment, and (3) silent-wait-time after a posed question. Higher inquiry teaching patterns, more pupil-initiated-response, and greater use of materials seemed to be related to a teacher's process orientation. Analyses also showed that a 32-hour instructional sequence effected an attitudinal change and an increase in process knowledge, although no significant change in teaching behavior except for a strengthening of an inherent questioning technique.

The conclusions point to future research in replications with other subjects, in the pursuit of discovering more interactions of process knowledge with teaching behaviors, and in the development of more definitive measuring devices.

A STUDY OF RELATIONSHIPS AMONG VERBAL INTERACTION, STUDENT ACHIEVEMENT, AND ATTITUDE IN SELECTED TWO AND FOUR YEAR COLLEGE GENERAL CHEMISTRY CLASSES

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The purpose of this research was to study the relationships among verbal interaction, student background, student achievement, and student attitude toward the course and teaching in selected two and four year college general chemistry classes. The success of transfer and native students in their advanced chemistry courses in selected four year colleges was also investigated.

Nine hundred and seventy-three students in five general chemistry lecture classes, and students attending five general chemistry tutorial classes at the City College of the City University of New York (C.C.N.Y.); 48 students in four general chemistry lecture classes at Borough of Manhattan Community College of the City University of New York (B.M.C.C.); 188 students in seven general chemistry lecture classes at Nassau Community College (N.C.C.); and 204 students in two general chemistry classes at the State University of New York at New Paltz (S.U.N.Y. New Paltz), were studied.

In September, 1971 these students responded to: the 1969 ACS-NSTA High School Chemistry Examination; Hand's Scale to Study Attitudes toward College Courses; The Purdue Instructor Performance Indicator; and a Chemistry Background Questionnaire from which the students' high school average, high school chemistry course grade, and New York State Chemistry Regents exam scores were learned. Throughout the term six hours of each lecture section and three hours of each totorial section were tape recorded. In January, 1971, some students retook the ACS-NSTA exam, while all students retook the attitude toward the course and teacher scales. The final grades of all students in the general chemistry courses were recorded. The chemistry background and experience of the general chemistry professors were recorded on a Teacher Background Questionnaire.

The tape recorded classes were coded and analyzed according to Flander's Method of Interaction Analysis. Within each school, sections were grouped into higher and lower I/D groups. The achievement, attitude toward the course and attitude toward the teacher of students in the higher and lower I/D groups were compared by analysis of covariance. Post ACS-NSTA scores and final grades were adjusted by pre-ACS-NSTA scores to determine achievement. Post course attitude scores were adjusted by pre-course attitude scores, and post teacher attitude scores were adjusted by pre teacher attitude scores.

For the general chemistry students in the four schools, the product moment correlation coefficient "R" was calculated between the following variables: post course attitude and success in general

chemistry, success being measured by final grade and ACS-NSTA post test; post teacher attitude and success in general chemistry; chemistry background and success in general chemistry, chemistry background being measured by high school chemistry course grade, high school New York State Regents Chemistry grade, and ACS-NSTA pre-test; high school average and success in general chemistry; chemistry background and pre-course attitude.

The significant results of these analyses showed at N.C.C. that the achievement of the higher I/D group was greater, 0.01 level, than the lower I/D group. In no college was the course attitude of the higher and lower I/D groups significantly different. At N.C.C. the teacher attitude of the lower I/D group was greater, 0.05 level, than that of the higher I/D group. There were positive significant relationships between post-course attitude and final grade, 0.05 level and post-course attitude and post ACS-NSTA scores, 0.01 level, at C.C.N.Y.; and post-course attitude and post ACS-NSTA scores, 0.05 level, at N.C.C. At N.C.C. there was a positive significant relationship, 0.05 level, between post-teacher attitude and post ACS-NSTA scores. In all four schools there was a positive significant relationship, 0.01 level, between ACS-NSTA pre-test and final grades. At C.C.N.Y. and N.C.C. there was a significant positive correlation, 0.01 level, between high school chemistry grade and final grade. At C.C.N.Y., N.C.C. and S.U.N.Y. New Paltz, there were significant positive correlations, 0.01 level, between New York State Regents Chemistry grade and final grade. C.C.N.Y., N.C.C. and S.U.N.Y. New Paltz, all showed significant positive correlation, 0.05 level, between high school average and final grade. At C.C.N.Y. there was a significant positive correlation, 0.05 level, between ACS-NSTA pre-test and pre-course attitude.

In the advanced chemistry courses at C.C.N.Y. and S.U.N.Y.New Paltz the grades of native and transfer students were compared and subjected to a "t" test. The grades of the native students at C.C.N.Y. were significantly higher, 0.05 level, than those of the transfer students.

The important <u>general conclusions</u> from this research are:

1. There will be a significantly greater achievement in the higher I/D group if there is a significant difference in I/D ratios between the higher and lower I/D classes in general chemistry, if the higher I/D classes are exceptionally indirect.

2. Students exposed to the more indirect teaching encountered in tutorials have greater success in the general chemistry course.

3. Teachers of the smaller classes in the two year colleges have generally higher I/D ratios than teachers of the larger classes in the four year colleges.

4. The attitude toward the course is generally more favorable in the higher I/D groups.

5. The attitude toward the first term of the general chemistry course is negative in both two year and four year colleges.

THE EFFECT OF INTERACTION ANALYSIS TRAINING AND FEEDBACK ON ASPECTS OF SCIENCE TEACHER CLASSROOM INTENTIONS, PERCEPTIONS AND BEHAVIORS

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The purpose of this study was to determine if:

1. Teachers perceive, desire and display the same classroom interaction patterns.

2. Students perceive, desire and display the same classroom interaction patterns.

3. Students and teachers perceive or desire classroom interaction differently.

4. Teachers receiving feedback and/or training in interpretation of interaction analysis would change their displayed, perceived and/or intended classroom interaction patterns in order to make them more consistent.

5. Teachers in the control group would change their displayed, perceived and/or intended classroom interaction patterns to make them more consistent.

Thirty-three junior high school science teachers from Western New York who were willing to have their classes audio-taped participated in the study.

Pre- and post-treatment period measures were given to all groups to determine the teacher's and student's displayed, perceived and desired classroom behaviors. The behaviors selected to describe classroom interaction were the inquiry, indirect/direct, motivation/motivation-control, student/teacher talk and activity/talk ratios. All of the above measures were compared to determine their consistency via the t-test of paired observations using 0.025 as the significance level. A modification of Flanders' Interaction Analysis System was used to determine displayed classroom interaction. Student and teacher measures required them to indicate the percent of class time they desired or perceived was spent in the same behavioral categories that the interaction analysis system used.

Three groups were formed by random assignment of the participating teachers. One group received both training in the interpretation of interaction analysis and interaction analysis feedback for one class a week for six weeks. A second group received only training in the interpretation of interaction analysis; and the third group received no treatment.

The results indicate that:

1. Teachers do not display, perceive and intend the same amount of time spent in the classroom behaviors except for the motivation/motivation-control ratio.

2. Students do not display, perceive and desire the same amount of time spent in the classroom behaviors except for the indirect/direct ratio.

3. Teachers tended to desire and perceive greater classroom behavior ratios than their students.

4. Teachers receiving training in the interpretation of interaction analysis and feedback tended to reduce the difference between their displayed-perceived and displayed-intended comparisons.

5. Teachers receiving only training in interpretation of interaction analysis tended to increase the difference between their displayed-perceived and displayed-intended comparisons.

6. Teachers in the control group maintained about the same difference between their displayed-perceived and displayed-intended comparisons.

It is evident that where junior high school science teachers who are willing to have their classes audio-taped have adequate knowledge of dissonance between their classroom behavior intended, perceived and displayed, the teachers can decrease this dissonance. Also, when teachers are called upon to teach a new course requiring specific types of classroom interaction, it would be valuable to know if the teacher actually desires, perceives and displays that behavior.

Session IVd - Teacher Characteristics, English Room

Chairman: Sidney P. Smith, Georgia State University, Atlanta, Georgia

1. "Pupil Rating of Pre-Service Science Teachers," Clarence Boeck, University of Minnesota, Minneapolis, Minnesota.
2. "A Study of Value Orientations as a Characteristic of Secondary School Students and Teachers of Chemistry," Peter H. Huston, University of Western Ontario, London, Ontario, Canada.
3. "Elementary School Science Programs: Pupil and Teacher Attitudes," Jerry A. Jenkins, Institute for Educational Research, Downers Grove, Illinois.

PUPIL RATING OF PRE-SERVICE SCIENCE TEACHERS

Clarence Boeck
University of Minnesota
Minneapolis, Minnesota

Can seventh and eighth grade pupils provide usable ratings of pre-service science teachers? What do they consider to be characteristics of good science teachers? Do pupils use these criteria when they rate science teacher performance? Answers were sought during the micro-teaching sessions of science education juniors at the University of Minnesota in 1970 and 1971.

Fifteen statements, descriptive of teacher personality, pupil-teacher relationships, teaching procedures, and classroom control were randomly assigned into sets of five items each. Each pupil marked one set for each teacher daily in sequences which provided a full rating every five days. Each teacher was also evaluated daily by combining the ratings of three pupils. With only five items to check, time requirements were minimal. Teachers were not rated the same on all items nor the same each day. Neither were all teachers rated the same on any trait. They were, to the pupils, individually unique, differentially effective, and changing daily.

In a final evaluation scheme, pupils were asked to describe a good science teacher. They were asked to identify the microteacher they would most like as a regular teacher and the most improved micro-teacher and to cite reasons for their choices. Reactions to the evaluation procedures were also elicited. Their statements, descriptive of a good science teacher, were categorized under the same headings used in classifying the items of the daily rating sheets. Teaching procedures was the most frequently used category; classroom control the least. From among the twenty microteachers in 1970, seventh graders identified seven as both wanted as regular teacher and most improved while eighth graders gave two this dual distinction. Six of the twenty-six micro-teachers in 1971 were selected as satisfying the double role.

Daily rating patterns of teacher behavior traits were consistent with pupil selection of wanted as regular and most improved teachers. They used the same criteria in their open-ended critiques of these teachers and the descriptions of a good science teacher. For the 1970 microteachers who were near-unanimous choices as most improved among the group the most stated reason for improvement was decreased nervousness, followed by "I learned a lot" and "used experiments". They also had the greatest number of changes in daily ratings. Those consistently chosen as wanted as regular teacher were noted to have stable patterns for traits such as friendliness, interest in teaching, and maintaining pupil interest.

Microteachers in 1971 who saw their daily ratings after completion of all their teaching generally accepted them as honest and valid appraisals. They felt the ratings gave them a picture of their

work which would be helpful in their student teaching. Even those with misgivings regarding their accuracy found the ratings supportive at a time when reinforcement was desirable.

It was found that seventh and eighth graders made conscientious and consistent ratings of pre-service teachers using the same criteria as student teaching supervisors. Their ratings hold promise in evaluating microteaching and predicting success in student teaching.

A STUDY OF VALUE ORIENTATIONS AS A CHARACTERISTIC OF SECONDARY SCHOOL STUDENTS AND TEACHERS OF CHEMISTRY

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Recent high school science curricula have emphasized theoretical aspects of science at the expense of humanistic and technological aspects. This emphasis on the theoretical appeared to be at variance with student values and contributed to seeming lack of relevance and resultant decreasing student interest. Stress on humanistic aspects of science was not only in accordance with the spirit of scientific inquiry but, while helping to bridge the gulf between the humanistic and scientific communities, would integrate these outlooks within individuals to help them perceive the unity of science with all of life. Similarly, more stress on the technological aspects of science would promote student interest and prevent divorce of science from the real world. However the relative importance which either students or teachers perceived in the various value components of science had not been reported.

An individual holds many values simultaneously, but as Maslow has indicated, a study of preferences may be used to study values and thus their relative strengths.

This study measured and compared the value orientations of students and teachers of secondary school chemistry to the theoretical, humanistic and technological aspects of chemistry. To do this a Chemistry Preference Evaluation Instrument of 24 sets of alternative statements was developed, containing in each set alternatives stressing the theoretical, humanistic and technological aspects of particular chemical phenomena or facts. The content validity of the instrument was established by the categorization of a panel of five experts. The construct validity of the instrument was supported by the significantly higher humanistic scores of Theology students and the significantly higher theoretical scores of Engineering Science students.

The instrument was administered to 120 grade 12 chemistry students in secondary school A in London, Canada and to 39 chemistry teachers employed by the London Board of Education. The reliability coefficients, all significant at the .001 confidence level, were: humanistic .85 and .78; theoretical .90 and .85; technological .77 and .72 for students and teachers respectively.

Female students scored significantly higher on the humanistic whereas male students scored significantly higher on the technological. A higher humanistic and technological orientation was associated with fewer courses in university chemistry teacher preparation and a greater number of years teaching experience, whereas a higher theoretical orientation was associated with a greater number of courses in university chemistry preparation and fewer years teaching experience. The teaching of biology was associated with higher technological and lower theoretical orientations.

Teachers viewed the theoretical aspects as significantly more important than did students, who viewed the humanistic and technological aspects as more important.

	Teachers	Students
Humanistic Value Orientation	21.0	30.1
Theoretical Value Orientation	30.6	17.3
Technological Value Orientation	20.2	26.1

The difference in the means for teachers and students was significant at the .001 confidence level in each case.

According to the descriptions of modern curricula as abstract and theoretical, the curricula coincided more closely with the value orientations of teachers rather than students. The implications for curriculum revision were apparent since students had clearly demonstrated their selection of the humanistic and technological in preference to the theoretical.

Specific contributions of the study to construction of teacher preparation programs for chemistry teachers includes recognition of the variance in value orientation with differing levels of university chemistry preparation. The identification of significantly different student and teacher value orientation adds another dimension to the cognizance of student perspectives developed during teacher preparation.

ELEMENTARY SCHOOL SCIENCE PROGRAMS:

PUPIL AND TEACHER ATTITUDES

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An investigation was conducted in ten suburban Chicago elementary school districts, grade levels two through six, to ascertain information about specific attitudes of pupils and teachers toward the elementary school science programs offered within their schools. Over 1600 children and 152 teachers representing more than 200 classes participated in the study. Information was gained from children regarding their interest in, satisfaction with, awareness of the goals of, and perceived difficulty of the science lessons. In addition, their curiosity about or interest in four science areas was measured and they were surveyed for an overall evaluation of their science programs. Teachers were inventoried regarding their satisfaction with science program objectives, content, activities, materials, and administrative support. They also supplied information concerning the extent of general satisfaction with their science programs. Finally, cost and administrative data related to each program were gathered.

The programs studied were those offered by AAAS, ESS, SCIS, and local programs using a single textbook, several textbooks, and no textbooks but following locally devised outlines. The data were gathered employing four instruments (including a semantic differential) and a survey schedule. The information gained was subjected to various statistical analyses, based on the forms of the data and on the nature of the questions being investigated.

The data analyses disclosed the following results:

1. The pupils were generally dissatisfied with their science lessons, stating that they learned a great deal from the lessons, but did not enjoy them.

2. The children overall expressed a low level of interest in science, though they conceded that science lessons were important.

3. No differences were detected in responses of children within the various science programs regarding awareness of the goals of the science lesson. For the most part, the pupils did not know what the goals of the lessons were.

4. The pupils did not believe the science lessons to be particularly difficult.

5. Among the programs surveyed, pupils demonstrated no preferential interest in or curiosity about any one or more science areas measured (biology, earth science, the universe, or physical science) over any of the others.

6. Although teachers recognized the need for science instruction, they conceded that little time was devoted to it.

7. Teachers expressed greater satisfaction with the objectives, content, activities, and materials of the commercially developed science programs than did those following locally devised or textbook programs. Strong dissatisfaction was voiced by those following local outlines.

8. School resources employed in elementary science instruction were, judging from results of this study, comparatively insignificant. In some schools, science exists in name only, with little or no time and effort devoted to it.

The implications of the results of this study are ominous. Pupils are not being provided opportunities to develop the skills, understandings, and attitudes of science to the degree that they value them. Thus the pupils cannot use the contributions science education has to offer in other educational and life endeavors. As a result, scientific literacy is delayed and perhaps never fully realized by the students. Certainly at a period in which children's attitudes are most susceptible to influence, little is being done to develop their attitudes toward science.

CONCURRENT SESSION V

Session Va - Student Achievement, Regency Room

Chairman: Mary Sweeney, University of Pittsburgh, Pittsburgh, Pennsylvania

1. "The Extent to which Pupils Manipulate Materials and Attainment of Process Skills in Elementary School Science," Douglas R. MacBeth, Lewisburg School District, Lewisburg, Pennsylvania, and H. Seymour Fowler, Pennsylvania State University, University Park, Pennsylvania.

2. "The Effects of Science - A Process Approach on the Oral Communication Skills of Disadvantaged Kindergarten Children," Phyllis E. Huff, Purdue University Calumet Campus, Hammond, Indiana, and Marlin Languis, Ohio State University, Columbus, Ohio.

3. "Pupil Achievement in Science A Process Approach - Part E," William Torop, West Chester State College, West Chester, Pennsylvania.

4. "Prediction of First Grade Science Achievement," Howard Poole, Lake Michigan College, Benton Harbor, Michigan, and John Feldhusen, Purdue University, West Lafayette, Indiana.

5. "Student Performance on Self-Instructional Modules in Preservice Elementary Science Methods Classes," Carlton W. Knight, II, University of Delaware, Newark, Delaware.

THE EXTENT TO WHICH PUPILS MANIPULATE MATERIALS AND ATTAINMENT OF PROCESS SKILLS IN ELEMENTARY SCHOOL SCIENCE

Douglas R. MacBeth
Lewisburg School District
Lewisburg, Pennsylvania

and

H. Seymour Fowler
Pennsylvania State University
University Park, Pennsylvania

For several decades, educators and psychologists have realized that direct manipulative experiences by young children are important to the child in certain learning situations. Further, it is generally agreed that at least two factors may influence the significance of this kind of experience: (1) the age and developmental level of the child, and (2) the nature of the learning task. However, the experimental research related to these two factors and the importance of this manipulative experience is scanty. The authors of the newer elementary school science curricula, although advocating first-hand involvement, direct participation, and an opportunity for the youngsters to manipulate science materials, present little empirical research that suggests that pupils will perform better using these programs if they indeed do directly handle the materials.

The study reported in this paper was designed to test the importance of this manipulative experience in the attainment of science process skills for kindergarten and third grade students.

In designing a study to investigate the importance of manipulative experience in the attainment of process skills for elementary school youngsters, several factors were considered. First, the teaching-learning situation should resemble, as closely as possible, that found in the typical self-contained classroom. Second, science lessons should be used that are part of a widely used, process-oriented curriculum. Third, groups of children that are likely to be in Piaget's "pre-operational" and "concrete-operational" stages should be selected.

Exercises chosen from the Science--A Process Approach program were taught in kindergarten and third grade classrooms. During the teaching of the exercises, certain pupils were allowed to manipulate the science materials while others were not. Following the teaching of each exercise, a competency measure was administered to assess the pupils' achievement of certain process tasks. Using a method of alternating subject treatment condition with exercise, an experimental design was constructed that placed each student in both the manipulator and non-manipulator roles. Mean scores on the exercise competency measures for each treatment condition were computed and tested for significant differences using the t-test for related measures.

The data collected from the kindergarten and third grade experiments suggest two basic conclusions:

1. Kindergarten children (ages 5-6) directly manipulating science materials attain science process skills better than children not manipulating these materials.

2. The attainment of science process skills by third grade children (ages 8-9) directly manipulating science materials is not significantly (α=.05) better than the attainment by children not manipulating these materials.

These observations are supportive of the theoretical literature that suggests that children in Piaget's "pre-operational" stage must operate on concrete objects. And that, as they mature, children become less dependent on manipulative learning and more on verbal learning. Although this may not be universally true, it seems to be supported for the learning of science process skills.

THE EFFECTS OF SCIENCE - A PROCESS APPROACH ON THE ORAL COMMUNICATION SKILLS OF DISADVANTAGED KINDERGARTEN CHILDREN

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and

Marlin Languis
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The problem investigated was to measure the effects of participation in the activities of Science - A Process Approach on the oral communication skills of disadvantaged kindergarten children.

Two research hypotheses were tested in this study:

1. Disadvantaged kindergarten subjects who have participated in activities of Science - A Process Approach, will, when compared with subjects who have not participated in S-APA activities, show significantly greater posttest scores on total oral transmitting skills and on the following oral transmitting subskills:

   A. Language Output and Expressiveness
   B. Vocabulary
   C. General Meaning and Ideas
   D. Sentence Structure
   E. Defining Words
   F. Average Length of Sentences

2. Disadvantaged kindergarten subjects who have participated in activities of Science - A Process Approach will, when compared with subjects who have not participated in S-APA activities, show significantly greater posttest scores on total receiving skills and on the following oral receiving subskills:

   A. Listening Behavior
   B. Listening Comprehension

The subjects were 113 kindergarten children enrolled in four regularly scheduled kindergarten classes, two morning and two afternoon, in an innercity school. Two of the classes, one morning and one afternoon, were randomly assigned to the experimental treatment. The remaining two classes were designated as control groups. The subjects were administered a pretest, given twelve weeks of treatment, and administered a posttest. The test used was the Test of Oral Communication Skills,

TOCS, developed by the investigator. The TOCS yields:

I. Total test score
II. Oral transmitting skills score
III. Six oral transmitting subskills scores:

A. Language output and expressiveness
B. Vocabulary
C. General meaning and ideas
D. Sentence structure
E. Defining words
F. Average length of sentences

IV. Total oral receiving skills scores
V. Two oral receiving subskills scores:

A. Listening behavior
B. Listening comprehension

Validity and reliability for the TOCS were determined through a pilot study.

The treatment consisted of twenty-two lessons, exercises a through k, of Part A, Science - A Process Approach for the experimental groups and twenty-two lessons from Springboards to Science, a teacher-demonstration, class-discussion oriented kindergarten resource book, for the control groups. All lessons for both control and experimental groups were taught by the investigator.

The one-way analysis of variance of pretest scores produced no significant differences among the four groups for any skill or subskill of the TOCS. The analysis of covariance or posttest scores revealed significant differences favoring the experimental groups ($> .01$) on total oral transmitting skills and oral transmitting subskills: language output and expressiveness, vocabulary, and general meaning and ideas, and ($> .05$) defining words. Significant differences favoring the experimental groups ($> .05$) were also found for total oral receiving skills and the oral receiving subskill: listening behavior. The Tukey (b) test, used to search for the source of the differences, showed both experimental groups to be significantly higher ($> .01$) than both control groups on the total transmitting skills and on oral transmitting subskills: language output and expressiveness, vocabulary, and general meaning and ideas. Finally, for every TOCS skill and subskill score, performance of the two experimental groups exceeded that of the two control groups.

In conclusion, both experimental hypothesis one and hypothesis two are accepted for total oral transmitting and total oral receiving skills. Hypothesis one is accepted for oral transmitting subskills A-E and rejected for subskill F, and hypothesis two is accepted for oral receiving subskill A and rejected for subskill B.

Within the parameters of this study, it may be confidently concluded that when the activities and teaching strategies of the S-APA program are presented to disadvantaged kindergarten children, their oral communication skills, especially the transmitting skills, are clearly enhanced.

PUPIL ACHIEVEMENT IN SCIENCE

A PROCESS APPROACH - PART E

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The problem considered in this study was to determine to what extent elementary school children were achieving the objectives of Science A Process Approach (SAPA) in grade four.

The subjects were fourth grade pupils in the seven elementary schools of Marple Newtown School District, Newtown Square, Pennsylvania, during the school year 1970-1971. Two pupils, selected randomly, in each class for each Part E SAPA exercise taught, were given the competency measure for the particular exercise. A total of 404 tests were thus administered.

The average percentage of correct responses in the fourth grade was 82%. Percentages were also computed for individual exercises in Part E.

SAPA was originally designed so that 90% of the pupils should achieve 90% of the stated objectives. There has been no large scale evaluation of the final version of Part E. The evaluation report of the experimental version indicated that Part E was less successful than Parts A through D. However, the final version of Part E is as successful as the other parts in Marple Newtown and will be compared, in detail, to Parts A through D.

Figures for individual exercises indicate which exercises might need improvement--either in the exercise itself or the competency measure.

PREDICTION OF FIRST GRADE SCIENCE ACHIEVEMENT

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and

John Feldhusen
Purdue University
West Lafayette, Indiana

The purpose of the present investigation was to screen large numbers of variables thought to influence first grade science achievement. The variables were grouped by their position in the educational environment of the first grade student and by major test scores. The subsets of variables included the educational institution (both qualitative and quantitative variables), the instructional characteristics, student biographical characteristics, teacher estimates of student ability and sociopersonal adjustment, and major test scores. The major test scores measured student mental ability, listening ability, academic achievement, sociopersonal adjustment, and previous science achievement. The criterion of science achievement was the science subscore of the Wabash Valley Education Center Science Test given at the end of the first grade school year.

A total sample of 240 students was used in the study. The sample was randomly divided into a validation and cross-validation sample. The students represented a population of sixty-five first grade classrooms located in an eleven county area of a midwestern state. The students were primarily from a semi-rural background.

Data for this study were analyzed using a stepwise linear multiple regression technique. The significance of sets of predictors and of differences between R values was determined using an F-test. Results of the regression problems were cross-validated on an appropriate sample to determine the stability of the prediction equation.

The results obtained from this research indicate that science achievement can be predicted at the first-grade level. First-grade science achievement, as measured by the science subscore of the WVEC Science Test, was predicted successfully by a group of major test score variables (R = .61), by a group of teacher estimates of student ability and sociopersonal adjustment (R = .51), and by a group of student biographic variables (R = .39). The major test scores variable prediction (R = .61) was increased significantly by the addition of selected variables from the teacher estimate group and one variable from the instruction group (R = .66). Other variables from the instruction group and those for the institutional groups failed to predict first-grade science achievement successfully. These findings suggest that the prediction of science achievement is not unlike the

prediction of other academic subjects. These findings also suggest that a restudy of the present national priorities for the improvement of science instruction and achievement is needed.

The most important variables in the prediction of first-grade science achievement were two mental ability scores. Logical reasoning and memory scores significantly accounted for the majority of the predictive variance. The WVEC pretest science score was the next greatest contributor to the prediction of science achievement. An instructional variable related to the test development of the WVEC Science Test, audio-tutorial instruction, was also found to be a possible source of variance. The remaining unique variance in the prediction of science achievement came from teacher estimates of the student's self-image and likelihood of social success.

In general, this study presented evidence that students who have high mental ability and previous science achievement were the more successful science achievers. Evidence was also found that suggests the present priorities of curriculum improvement, instructional improvement and the improvement of academic facilities do not contribute to first-grade science achievement. Further research on a more comprehensive scope will be needed to confirm these findings.

STUDENT PERFORMANCE ON SELF-INSTRUCTIONAL MODULES IN PRESERVICE ELEMENTARY SCIENCE METHODS CLASSES

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The purpose of this research was to compare the performance of elementary science methods classes on selected instructional modules presented through treatments representing teacher directed and self-instructional study guide activities.

The procedures yielded comparative achievement data for three intact methods groups A, B, and C of 24, 25, and 29 students respectively. These groups were presented four instructional modules by three different treatments. Within each module students attempted to perform specified behavioral competencies. Pre and post measures were administered to determine the incidence of gain, loss, and no change for each competency.

In Phase I, treatment one was used to present the instructional modules Observing (four competencies) and Inferring (five competencies) to all groups. Students studied each module through a methods textbook and participated in teacher directed experiments and discussions. Following uniform instructional periods, the respective competency measures were administered.

During Phase II the instructional modules Measuring (four competencies) and Communicating (five competencies) were presented to all groups through different treatments. Group A continued using treatment one. Group B experienced treatment two in which the textbook was supplemented with a self-instructional study guide, however, no module related activities were conducted during the regular class periods. Instructional treatment three, administered to Group C, combined the treatment one teacher directed activities with the self-instructional study guide. Competency tests were administered following completion of Phase II. One instructor taught all groups on the same days but at different times. The carry-over effect of the unique study guide, however, prevented application of the treatments to all groups in rotating sequence.

The results were obtained from a pairwise comparison of all combinations of groups (A-B, A-C, B-C) for each behavioral competency in Phase I (similar treatments) and Phase II (differential treatments). Low expected frequencies in too many cells prevented application of chi square, therefore, the pairwise comparison for each behavioral competency was used to identify significant differences ($p < .01$) between the various groups with respect to: (1) regression - the percent of students passing the pretest but subsequently failing the post test, and (2) improvement - the percent of students failing the pretest but passing the post test.

Of 54 pairwise comparisons computed from Phase I data, only two comparisons were significant at the .01 level. The improvement rate for Group C surpasses Group A for Observing competency number 4 and the improvement rate for Group B surpassed that of Group A for Inferring competency 3b. There were no significant differences for any of the 54 pairwise comparisons from the Phase II (differential treatment) data.

The presence of several contaminating variables (e.g., university computer scheduling of students and the previously described limitations which prevented scheduling of treatments in rotating sequence) suggest the results are tentative and further investigation should be conducted under more rigorous controls. These data, however, imply that for the above groups, substitution of self-instructional study guides for various teacher directed inclass activities did not result in significant differences in the proportion of each group experiencing pre-post test behavioral competency regression or improvement.

Session Vb - Student Achievement, Ivy Room

Chairman: Floyd M. Read, East Carolina University, Greenville, North Carolina

1. "An Analysis of the Pass-Fail Grading System as Compared to the Conventional Grading System in High School Chemistry," Louis A. Gatta, University of Iowa, Iowa City, Iowa.
2. "The Effect of the Timing of the Presentation of Two Subordinate Informational Concepts on the Cognitive Process of Synthesis," Clifford L. Schrader, Dover High School, Dover, Ohio.
3. "An Analysis of the Relationship which Exists Between Cognitive and Affective Educational Objectives in Selected Biology Classrooms of Wayne County, Michigan," Norville H. Schock, Southeastern High School, Detroit, Michigan.
4. "The Use of Science Classes for Teaching Self-Evaluation of Performance," Judy C. Egelston and Richard L. Egelston, State University of New York, Geneseo, New York.
5. "Some Correlates of Development and Retention of Critical Thinking Ability in Seventh Grade Science Students," Donald Gudaitis, Westfield Public Schools, Westfield, New Jersey, and Hulda Grobman, New York University, New York City, New York.

AN ANALYSIS OF THE PASS-FAIL GRADING SYSTEM AS COMPARED TO THE CONVENTIONAL GRADING SYSTEM IN HIGH SCHOOL CHEMISTRY

Louis A. Gatta
University of Iowa
Iowa City, Iowa

The purpose of this study was to analyze the effect of a pass-fail grading system on achievement in chemistry and attitudes towards chemistry. An additional objective was to examine whether or not there was a different effect produced by the pass-fail grading system at different achievement levels. The achievement levels were determined by the students' previous grade point average.

One hundred ninety-six students, enrolled in chemistry, were selected from a representative suburban high school in the Chicago area and divided into two groups; one group was graded on the pass-fail grading system and the other group was graded on the conventional grading system. There were eight sections of chemistry and two teachers taking part in this study. Each group in the study consisted of four sections. The teachers had two sections on the pass-fail system and two sections on the conventional system.

Four instruments were used to compare the pass-fail grading system with the conventional grading system in chemistry. These instruments were:

(1) ACS - NSTA Cooperative Examination High School Chemistry Form 1969

(2) Achievement Tests for Chemistry: Experiments and Principles Series 1

(3) Attitude Toward Any School Subject

(4) Science Classroom Activity Checklist

The data were collected during the first semester of the 1970-71 academic year. A treatment by levels design was used to analyze the data collected for all achievement measures used in this study. The data collected for the attitude measure were analyzed using a treatment by levels design with covariate control and a 2x2 analysis of variance was used to analyze the Science Classroom Activity Checklist. The results of such analyses indicated:

(1) Students in the conventionally graded classes achieved course principles and concepts to a significantly greater degree than those students in the pass-fail class as measured by the achievement tests for Chemistry: Experiments and Principles.

(2) Students in the conventionally graded classes achieved principles and concepts deemed important by the American Chemical Society and chemistry teachers who were members on the National Science Teachers Association, to a significantly greater degree than the students in the pass-fail graded sections as measured by the ACS - NSTA Cooperative Examination High School Chemistry Form 1969.

(3) Students in the conventionally graded section showed significantly better attitudes towards chemistry than the students in the pass-fail graded classes as measured by the Attitude Toward Any School Subject.

(4) The teachers used in this study did not use different methods while teaching the pass-fail graded course or the conventionally graded course as measured by the Science Classroom Activity Checklist.

(5) The teaching methods used by both teachers were the same as measured by the Science Classroom Activity Checklist.

The Scheffé test was used to investigate the effect of the pass-fail system on the high, middle, and low achievement level. Results of the analyses indicated the pass-fail system had its greatest effect on the students in the high achievement level. They performed significantly lower than the students in the conventional system on all measures of achievement and attitude. The middle achievement level showed no significant differences between the two groups and the general trend of lower achievement and poorer attitudes prevailed for the low level.

THE EFFECT OF THE TIMING OF THE PRESENTATION OF TWO SUBORDINATE INFORMATIONAL CONCEPTS ON THE COGNITIVE PROCESS OF SYNTHESIS

Clifford L. Schrader
Dover High School
Dover, Ohio

This study was designed to investigate the effect of the timing of the presentation of two subordinate informational concepts in the cognitive process of synthesis as defined in The Taxonomy of Educational Objectives, Handbook I; Cognitive Domain. A hierarchy was proposed for each of eight topics in chemistry using the method suggested by Gagné. Each hierarchy consisted of two informational concepts, A and B, and a third concept, C, which could be obtained by synthesizing A and B. The term informational concept refers to that information which is generalized and learned as a concept, and which can be combined with another informational concept to synthesize a new structure or concept not clearly there before. Both the relevant subordinate capabilities in the hierarchy and the synthesis task itself were measured.

Four sections of an introductory chemistry course of 88 high school students were used as the experimental population. The students were assigned to classes of approximately equal size by a computer on the basis of remaining space. Analysis of I.Q. scores gave no evidence of bias on this variable, since the mean I.Q.'s of each class did not differ and homogeneity of variance was confirmed. Analysis of I.Q. was chosen because I.Q. was found by previous researchers to correlate with the higher cognitive abilities such as the ability to synthesize. The correlation between I.Q. and ability to synthesize was found to be .36 in this study, which is significant at the .005 level.

The process of synthesis was investigated by using eight units of chemistry subject matter. In each unit the learner was taught informational concepts A and B. A test was given to determine if the learner had acquired both A and B, and if he could successfully synthesize them to produce C. In the first treatment group, X_1, the information was presented at separate times by providing written programmed learning material concerning A on one day, and similar material concerning B on the next day. One week later a written review of A was given, the following day a review of B was provided, and the next day the students were tested. In the second treatment group, X_2, the written programmed material concerning both A and B were reviewed and the following day the students were tested.

In three of the eight units a higher proportion of the students in treatment group X_2, were successful in synthesizing A and B at the .05 level. This supports Ausubel's theory that information is processed during storage and suggests that to maximize the ability of learners to synthesize, the information should be presented together.

AN ANALYSIS OF THE RELATIONSHIP WHICH EXISTS BETWEEN COGNITIVE AND AFFECTIVE EDUCATIONAL OBJECTIVES IN SELECTED BIOLOGY CLASSROOMS OF WAYNE COUNTY, MICHIGAN

Norville H. Schock
Southeastern High School
Detroit, Michigan

This analytical study was designed to investigate the relationship which existed between cognitive and affective educational objectives in twenty-eight biology classrooms drawn from seven public high schools. The investigation analyzed:

1. Cognitive and affective relationships
2. Biology class level and cognitive relationships
3. Biology class level and affective relationships
4. Motivation and cognitive relationships
5. Motivation and affective relationships

The Nelson Biology Test (Form E) was utilized to determine the extent to which cognitive educational objectives were attained. Pre and post-tests were conducted in three major cognitive categories - Knowledge (1.0), Comprehension (2.0), and Application (3.0).

The ASLT (A Scientific Literacy Test)Student Questionnaire was used to determine the extent to which affective educational objectives were attained. Pre and post-tests were conducted in three major affective categories - Awareness (1.1), Acceptance of a Value (3.1), and Preference for a Value (3.2).

The JIM (Junior Index of Motivation) Scale Student Questionnaire was utilized to assess student motivation to learn in school. One test administration was conducted mid-way between the pre and post-tests described above.

The resulting numerical scores were keypunched on cards and nineteen major hypotheses, which stemmed from the five major areas above, were analyzed statistically by using the statistical package CONSTAT (CONsole STATistics) at the Wayne State University Computing and Data Processing Center.

The following conclusions were reached:

1. The absence of a significant difference between female and male data for cognitive and affective development indicates that sex is not a factor in cognitive and affective development.

2. Even though very low positive correlations were obtained between cognitive and affective development, no significant statistical relationship exists. A possible inverse

relationship was suggested by the resulting mean values. This relationship was not supported, however, by the correlation coefficients. A significant statistical relationship does exist, though, between cognitive level 1.0 (Knowledge) and affective level 1.1 (Awareness).

3. Even though very low positive correlations were obtained between cognitive and affective development in three biology class levels, no significant statistical relationship exists.

4. Even though very low positive correlations were obtained between cognitive and affective development in four motivation levels, only motivation level 2 (second highest) produced a significant statistical relationship. Motivation level 3 (second lowest), although not statistically significant, was sufficiently close to being significant, and consequently warranted comment at this time. Thus, a relationship does not exist at the upper and lower extremities of motivation.

5. The significant difference in cognitive development between three biology class levels and their ascending pattern of mean values, indicate that a difference exists between biology class levels and that a direct relationship exists between biology class levels and cognitive development. The motivation mean values for each biology level indicate that a direct relationship also exists between biology class levels and motivation.

6. The significant difference in affective development between three biology class levels and the lack of an ascending pattern of mean values, indicate that a difference exists between biology class levels and that a direct relationship does not exist between biology class levels and affective development.

7. The significant difference in cognitive development between motivation levels and their ascending pattern of mean values, indicate that a direct relationship exists between motivation levels and cognitive development.

8. The significant difference in affective development between motivation levels and the lack of an ascending pattern of mean values, indicate that a relationship does not exist between motivation levels and affective development.

THE USE OF SCIENCE CLASSES FOR TEACHING

SELF-EVALUATION OF PERFORMANCE

Judy C. Egelston
and
Richard L. Egelston
State University of New York
Geneseo, New York

In an investigation of the accuracy of self-evaluation on test performance, two hundred ten students (grades 7-9) in eight general science classes and one earth science class from a rural Eastern New York secondary school were asked to predict their scores prior to and after taking each unit test.

At the beginning of the school year the teachers explained to the students that on each unit test the students would be asked to predict the percentage score they would get on the test immediately before (pretest prediction) and immediately after (posttest prediction) taking the test. Absolute differences between the two predictions and actual scores were the random variables analyzed. The number of tests given to each class ranged between eight and thirteen. All tests were constructed to be somewhat discriminatory in nature, and perfect scores were rarefly achieved.

Analyses of variance and Markov chain analyses revealed significant differences by achievement level, with practice, and in rate of improvement, but not by sex. All hypotheses were tested at the five percent level of significance.

It is particularly noteworthy that within the same trend analyses, contrasts of the last predictions with the first predictions were conducted, and found to be more accurate at the end of the year in seven of nine sections. Also, in the three ninth grade sections, the posttest predictions were significantly more accurate than the pretest predictions. Thus it appears that with practice and maturation students can learn to improve their self-evaluation of performance on cognitive tasks.

With the current emphasis given to rational decision making, it would seem important to be able to examine personal capabilities and self-performance in an objective light. The learning of techniques which improve the accuracy of self-evaluation appears to be a reasonable process to incorporate into the junior high school curriculum. Science classes may be the logical place to undertake this instruction, since objective measurement forms one of the cornerstones of this field.

SOME CORRELATES OF DEVELOPMENT AND RETENTION OF CRITICAL THINKING ABILITY IN SEVENTH GRADE SCIENCE STUDENTS

Donald Gudaitis
Westfield Public Schools
Westfield, New Jersey

and

Hulda Grobman
New York University
New York City, New York

A previous study compared development of student attitude, science process skills, and critical thinking ability in two seventh grade science programs, Interaction of Man and Biosphere (IMB) (experimental) and Science is Explaining (control).[1] The present study represents a follow-up in terms of a delayed post-test, to determine long-term gains for control and experimental groups, and the significant variables related to such gains. Variables to be examined include control and experimental treatments, IQ, initial critical thinking, sex, science attitude, and science process scores and initial changes in critical thinking, attitude, and science process scores.

The study population included two teachers and their eight classes from two suburban New Jersey junior high schools. Each teacher had two experimental and two control classes. The control and experimental groups each consisted of 48 boys and 48 girls. Instruments used were: Attitude Toward Any School Subject; Test of Science Processes; and Cornell Test of Critical Thinking was read-administered in early November of year 2, when the students were in eighth grade. (School turnover is relatively light, with 10 per cent of the cases lost through turnover during the 13 month period.)

Data analysis was through correlational and analysis of variance techniques.

In effect this study had two foci: First, the retention of critical thinking gains for students in two curricula. This is of greater significance than end-of-year gains, since the purpose of schooling is the development of long-term skills rather than of immediate, but soon forgotten gains. Second, the interaction of variables in seventh grade junior high science, as these were related to long term retention of critical thinking gains. A better understanding of such correlational relations in a science teaching situation will provide needed groundwork for further experimental studies aimed at improvement of science teaching.

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1 "The Effects of Two Seventh Grade Science Programs On Student Attitude, Science Processes, and Critical Thinking" (paper presented at Annual Meeting, NARST, Silver Springs Maryland, 1971)

Session Vc - Student Achievement, Envoy Room

Chairman: Rodney L. Doran, State University of New York at Buffalo, New York

1. "Specific Content Knowledge as a Primary Component of a Model to Describe Learning by Young Children," Kenneth M. Hibbard, Greenwich Public Schools, Greenwich, Connecticut, and Joseph D. Novak, Cornell University, Ithaca, New York.

2. "Elementary School Children's Level of Attainment of Selected Classificatory Concepts," Alan M. Voelker, The University of Wisconsin, Madison, Wisconsin.

3. "A Study of the Relationship of Knowledge of Geometry to Acquisition of Conservation of Liquid," Ann Howe, Syracuse University, Syracuse, New York.

4. "The Effect of Two Types of Science Instruction on Student Achievement, Perceptions, Retention and Extensional Learning," Robert E. Kilburn, Newton Public Schools, West Newton, Massachusetts.

5. "Similarities and Differences of Attitudes of Selected Groups of Underachieving Junior High School Students: An Interpretation of Q-Sort Test Data," Jack Megenity, Georgia State University, Atlanta, Georgia.

SPECIFIC CONTENT KNOWLEDGE AS A PRIMARY COMPONENT OF A MODEL TO DESCRIBE LEARNING BY YOUNG CHILDREN

Kenneth M. Hibbard
Greenwich Public Schools
Greenwich, Connecticut

and

Joseph D. Novak
Cornell University
Ithaca, New York

The Elementary Science Project, directed by Joseph D. Novak at Cornell University, has attempted to develop and assess science instruction for the elementary school. This approach is based on an interpretation of David P. Ausubel's subsumption learning theory. The primary characteristic of this subsumption theory is that it views a learner's specific content knowledge as being the crucial factor in learning.

The Elementary Science Project has attempted to assess children's knowledge of such phenomena as smells, air, and the differences between solids, liquids and air. A series of lessons dealing with the particulate model of smells, and the particulate nature of solids, liquids and air were developed.

Two types of assessment instruments were developed. The first was a paper-and-crayon picture test. Some questions were of the production type in that they asked the child to produce a drawing, e.g. one question asked the child to imagine he could see a smell and draw what a smell would be like. Other questions were of the recognition type in that they asked the child to select the best answer from several given alternatives. The second assessment instrument was an individual interview modeled after Piaget's revised clinical technique.

The instructed children showed high concept attainment on the concept of the particulate model for smells. 90% of these children described a smell as little parts coming from or out of the source, i.e. "the little parts of coffee come up out of the coffee and to my nose". None of the uninstructed children described a smell in this way. They usually suggested that the air turned into smell, i.e. "the air goes down into the cup and comes back out and then smells like coffee". Although the uninstructed children saw a casual relationship between the smell and the "source", they did not understand the specific physical relationship between a smell and its source.

Forty-five percent of the instructed children also learned a particulate model for solids, liquids, and air, while only 10% of the uninstructed children could use a model of this type. That fewer instructed children learned a model for solids, liquids, and air than learned a model for smells may be accounted by by the observation that these children seem to have less specifically relevant foundation

knowledge about solids, liquids, and air than they have about smells.

A novel transfer problem was devised, the answer for which required information about smells and the three states of matter. Seventy-one percent of the instructed children suggested acceptable solutions while only 32% of the uninstructed children were as successful. Of the 71% of the instructed children who were successful, 36% gave answers using a good particulate model. None of the uninstructed children used a particulate model to solve this problem.

Many of the first graders in this study attained concepts which are often thought too difficult for fourth or fifth grade children. Many children exhibited high concept attainment, indicating that this approach to curriculum development has been successful. Usually in the field of elementary science education, little effort is taken to ascertain the specific content knowledge which the children have. Children's knowledge is not often considered a very important factor regulating learning. Many curriculum writers suggest that the child's general mental abilities are the most important limiting factors to learning. While the general content-independent abilities may be limiting factors, this study suggests that as a process of curriculum development, much more attention must be given the child's specific content knowledge.

ELEMENTARY SCHOOL CHILDREN'S LEVEL OF ATTAINMENT OF SELECTED CLASSIFICATORY CONCEPTS

Alan M. Voelker
The University of Wisconsin
Madison, Wisconsin

The purpose of this study was to determine elementary school children's level of attainment of selected classificatory science concepts.* Related problems were:

1. to determine whether relationships existed among attainment of classificatory concepts in the biological, earth, and physical science areas and,

2. to determine whether there was a hierarchy of levels of attainment of classificatory concepts according to the nature of a concept and the respective science area.

Classificatory concepts from the biological, earth, and physical science areas in the fourth-grade texts of six commonly used elementary science series were identified. A 12-item test was constructed for each of the 30 randomly selected concepts, ten per science area. Each test item corresponded to one of these tasks.

1. Given the name of an attribute, select an example of the attribute.
2. Given an example of the attribute, select the name of the attribute.
3. Given the name of a concept, select an example of the concept.
4. Given the name of a concept, select a non-example of the concept.
5. Given an example of a concept, select the name of the concept.
6. Given the name of a concept, select a relevant attribute.
7. Given the name of a concept, select an irrelevant attribute.
8. Given the meaning of a concept, select the name of the concept.
9. Given the name of a concept, select the meaning of the concept.
10. Given the name of a concept, select the supraordinate concept.
11. Given the name of a concept, select the subordinate concept.
12. Given two concepts, select a principle relating them.

The 12 items for five groups of six concepts each were placed in random order, producing five 72-item testing instruments.

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*A classificatory concept possesses three characteristics:

1. there is more than one example of the concept,
2. the properties of the concept can be described, and
3. the concept can be labeled (named) by a word or a compound word.

A pilot study was conducted to estimate the reliabilities of the 30 concept tests and the 12 task tests. Revised tests have been administered to 186 fifth-grade boys and 259 fifth-grade girls, yielding test reliabilities in excess of minimums considered adequate for group administered tests.

Data are being analyzed to (1) determine the nature of the tasks that children can perform by concept and among the three science areas and (2) determine the nature of the tasks that children can perform in relation to the nature of concept formation in the respective disciplines.

A simplex analysis will be run to estimate whether there is a hierarchy in terms of task attainment. (Pilot study results indicated a progression of concept attainment similar to the arrangement of the 12 tasks.) A three-mode factor analysis will be run to determine the content and task dimensions of the respective science items.

Implications for improving educational practice are:

1. the development and refinement of a system for classifying science concepts,
2. providing knowledge about
   a. the relationships that exist among attainment of concepts in the biological, earth, and physical sciences,
   b. developing a concept attainment model to be employed in systems for organizing instruction,
   c. establishing reasonable expectations for children's attainment of specific science concepts, and
3. determining whether there is a hierarchy of concept attainment within and among classes of science concepts.

A STUDY OF THE RELATIONSHIP OF KNOWLEDGE OF GEOMETRY TO ACQUISITION OF CONSERVATION OF LIQUID

Ann Howe
Syracuse University
Syracuse, New York

Effective elementary science curricula must be based on knowledge of how children think as well as on knowledge of science. The work of Piaget and others indicates that young children think in unexpected ways and that logical thought processes are only gradually acquired during childhood. An important milestone in the growth of logical thinking is the acquisition of conservation, the knowledge that quantity remains the same through changes in shape. When children are asked to explain how they know that the amount of liquid or solid remains the same they often reply, in their own words, that the increase in one dimension is offset by a decrease in another dimension. Piaget seems to believe that conservation is acquired when a child becomes able to think about two dimensions at once in an intuitive, non-metric way. Learning theorists believe that conservation, like other knowledge, is acquired through a process of cumulative learning. Gagne has suggested a learning sequence for conservation of liquid (conservation of continuous quantity) which includes non-metric rules concerning the determination of area and volume, the effect of a change in one dimension, compensatory changes in two dimensions, and interior volume of a container.

The work described below was undertaken to elucidate the relationship of knowledge of geometric relationships to acquisition of conservation of liquid.

Second and third grade children were tested on their ability to make judgments of certain area and volume equivalences. The children were then presented with a conservation-of-liquid task. Fifteen of the children gave correct conservation responses but only two of these had solved the area and volume problems correctly. Therefore, it appears that knowledge of area and volume relationships is not necessary for acquisition of conservation of liquid. Indeed, a precise knowledge of these relationships is not usually acquired until children reach adolescence. Gagne also suggested that conservation of liquid in rectangular containers should precede conservation of liquid in cylindrical containers. In our sample, no child was found who gave the correct response for liquid in rectangular who did not also give the correct response for liquid in cylindrical containers. The proposed learning sequence, though logical, does not show the necessary dependencies to be considered valid.

Children's explanations for conservation can be categorized as a) Identity (It's the same water; nothing changed), b) Compensation (It's fatter but shorter), c) Reversibility (If you poured it back, it would be the same). When second-, third-, and fourth-grade children, all conservers, were asked to give their reasons for conservation responses, the results were as follows (percentages approximate):

Second grade: 90% Identity; Third grade: 50% Identity, 50% Compensation; Fourth grade: 80% Compensation. This is interpreted to mean that the explanations do not indicate how the children arrived at conservation but are, instead, justifications for what the children see as a logical necessity and that the explanations change over time as children's thinking becomes more logical. These results indicate that acquisition of conservation of liquid is not dependent upon knowledge of geometry, that once the concept is attained it is generalizable to other sizes and shapes of containers, and that the enlargement of understanding of a concept is reflected in language.

These findings are of theoretical interest and they also pertain to the content and method of elementary science education.

THE EFFECT OF TWO TYPES OF SCIENCE INSTRUCTION ON STUDENT ACHIEVEMENT, PERCEPTIONS, RETENTION AND EXTENSIONAL LEARNING

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Newton Public Schools
West Newton, Massachusetts

The purpose of this study was to compare seventh grade life science classes taught using two different types of instructional milieu. Treatment A consisted of guided discovery teaching with maximum emphasis on individual laboratory experiments, field work, and experiences with living and once-living specimens. Treatment B consisted of guided discovery teaching with maximum emphasis on demonstration experiments, films as substitutes for field experiences and the use of models and overhead transparencies as substitutes for experiences with real organisms.

Twenty-three classes and their eight teachers were used for the study. Each teacher taught both methods and participated in a three day workshop before teaching the unit to learn the content of the unit and the procedures to be used. The ten week instructional unit emphasized the study of insects and ecology. Classes, matched according to I.Q. test scores, reading level and science achievement, were randomly assigned to the two treatment groups.

Dependent variables in this study were (1) science content achievement, (2) science content retention, (3) science process knowledge achievement, (4) science process knowledge retention, (5) science perceptions and (6) extensional learning. Extensional learning is defined as the self-learning a student carries on, after the unit is over.

A pre, post, retention design was used for science content achievement and retention and for science process knowledge achievement and retention. In each case, investigator-developed instruments were administered; Form A as a pretest and Form B as a posttest with Form B readministered one year later as a measure of retention. Science perceptions were measured after the completion of the unit. This consisted of twelve concepts with sixteen scales for each concept of a semantic differential instrument. Extensional learning was measured one year after the unit was completed using an investigator-developed checklist.

A three factor, partially nested experimental design was employed. The factors were treatments (2), experience levels of teachers (2), and teachers within experience levels (4w.2). Analysis of variance and covariance was employed for testing hypotheses about differences in achievement and retention. Responses on the semantic differential instrument used to measure science perceptions were factor analyzed using principal components analysis and factor loadings obtained by varimax rotation.

Significant differences due to treatment effects were not observed for science content achievement posttest and retention tests at the .05 level. Significant differences on the content posttest did occur as a result of experience effects (in favor of experienced teachers), effects due to teachers within experience levels, and treatment by experience interaction (experienced teachers were more effective with treatment A, inexperienced more effective with treatment B). No significant differences of any kind were found affecting content retention.

Significant differences in process learning favored treatment B, a teaching style characterized by demonstrations, films and the use of models. Experience was also significant favoring experienced teachers. Teacher differences within levels of experience was also significant. Again, no significant factors were detected affecting retention.

The retention tests of content achievement and process knowledge achievement both involved retesting with the same instruments used as posttests. The drop in scores on content achievement was quite significant, indicating forgetting. The retention scores of process knowledge were higher than the posttest scores, indicating that any forgetting of science process knowledge was more than offset by additional learning.

The semantic differential data of the science perceptions test were analyzed using the responses of a random sample of 80 subjects from each treatment group. Coefficients of congruence were calculated for the factor loadings. Using accepted criteria and procedures, the conclusion was made that the perceptions of the subjects in the two treatment groups differed.

In summary, the only treatment differences observed in this study were (1) process knowledge learning was enhanced by an instructional milieu emphasizing demonstration teaching, films and the use of models and overhead transparencies, (2) students in the two treatments perceived science differently and (3) experienced teachers were more effective in teaching science content by a different method than were inexperienced teachers. The areas of science perception and extensional learning are suggested as deserving of more study.

SIMILARITIES AND DIFFERENCES OF ATTITUDES OF SELECTED GROUPS OF UNDERACHIEVING JUNIOR HIGH SCHOOL STUDENTS: AN INTERPRETATION OF Q-SORT TEST DATA

Jack Megenity
Georgia State University
Atlanta, Georgia

The central problem of this special research program, extending over a three year period and involving twenty different junior high schools, more than sixty teachers, and nearly two thousand students, had to do with attempting to change the attitudes of the students toward themselves, their teachers, their peers, and their school to a more favorable position.

The statistical hypotheses, tested at the 5% level of confidence by analysis of variance techniques applied to the collected data from the Q-sort test of this particular study, were:

1. The means of the Q-sort scores for attitudes toward self, teachers, peers, and school for treated, non-treated, black, white, male and female students are not significantly different.

2. There is no statistically significant interaction effect between treatment and race, between treatment and sex, and among treatment, race, and sex for attitudes toward self, teachers, peers, and school.

With experimental and control groups (treated and non-treated) selected at random from the population of underachievers, it was assumed that at the very start of the program the intensities of attitudes toward self, teachers, peers, and school held collectively by each of the group was equal. Also, with limitations of the Q-technique in mind and with the acceptance of the assumption that previous attitude tests of the students in this program did indicate a direction of attitude change, the following statements of interpretations and conclusions are made:

1. The intensity of positive attitudes held by the treated students toward teachers and school was increased.

2. The intensity of positive attitudes held by the treated students toward self and peers was increased, but not to the degree by which the intensity of their attitudes toward teachers and school was increased.

3. The success-oriented curriculum of the research program effected an increase in positive attitudes of the treated black and white alike, as well as the treated male and female.

4. The ordering the Q-sort items for the non-treated students show a preference for self and peers over teachers and school, indicating more successful experiences with peers than with teachers.

5. The desirable attitudinal changes toward teachers and schools for the treated students indicate success for the research program.

Session Vd - Symposium, English Room -- "Naturalistic Research" on Problems of Beginning Science Teachers

Chairman: Orrin Gould, University of Illinois, Urbana, Illinois

Recent work by University of Illinois (Urbana) science education faculty and graduates will be used to illustrate and elicit discussion of a"Naturalistic" attack to educational research.

Participants: Jack Ashenfelter, High School district 214, Mt. Prospect, Illinois

Beryl Craig, University of California, Riverside, California

Larry Guthrie, Komarek Elementary School, North Riverside, Illinois

R. Will Burnett, University of Illinois, Urbana, Illinois

John A. Easley, Jr., University of Illinois, Urbana, Illinois

Edward Jenkins, Southern University, Baton Rouge, Louisiana

Elizabeth A. Kendzior, University of Illinois, Urbana, Illinois

PRESIDENT'S ADDRESS Mayfair Room

A DARWINIAN LOOK AT SCIENCE EDUCATION
(Are We Fit to Survive?)

Frank X. Sutman
Temple University
Philadelphia, Pennsylvania

Science education and science are not held in esteem the way they were only a few years ago. There are a number of reasons for this; some philosophically based, others based upon the way science is taught. Misunderstanding and confusion about the meaning of inquiry as a teaching strategy has prevented advancement in the teaching of science.

The term inquiry has been interchangeably used to describe a question-answer teaching strategy and process oriented teaching. Defined in a simple and useful way inquiry is the asking of questions by students. In the normal discussion technique teachers generally ask the questions leaving little time for students to question. The correct use of inquiry in teaching can stimulate more interest in science and hence in science teaching.

Research in science education has given little return over the past 30 years. We must revise our thinking about the meaning of the term "rigorous" as applied to research. Also, we must concern ourselves with helping classroom teachers utilize the results of the research we do.

NARST can foster more immediately useful research by encouraging a broader spectrum of types of research to be completed and to be reported. Also, the Journal of Research in Science Teaching can encourage researchers to write a paragraph or two at the end of reports, submitted for publication that will explain to teachers how the research can be applied in classrooms. Finally, NARST can encourage continued activity of the newer members to the profession by accepting all doctoral level research for reporting at its national meetings.

CONCURRENT SESSION VI

Session VIa - Verbal Behavior, Ivy Room

Chairman: Paul A. Becht, University of Florida, Gainsville, Florida

1. "Higher Level Verbal Response and Higher Level Test Response of Biology Students and Their Relationship to Questioning by Biology Student Teachers," Catherine Becker, New York University, New York City, New York.
2. "A Study of the Effects of Teacher-Questioning Behavior on Pupil Critical thinking Ability in Three Academic Subjects Offered in a Suburban High School," Martin A. Cohen, New York University, New York City, New York.
3. "An Experimental Study of a Televised Science Series, Grades 1-4, Comparing the Quality and Sequence of Television and Classroom Questions with a Proposed Strategy of Science Instruction," Paul Beisenherz, Louisiana State University, New Orleans, Louisiana.

HIGHER LEVEL VERBAL RESPONSE AND HIGHER LEVEL TEST RESPONSE OF BIOLOGY STUDENTS AND THEIR RELATIONSHIP TO QUESTIONING BY BIOLOGY STUDENT TEACHERS

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New York University
New York City, New York

The purpose of this study was to determine whether there was a significant difference in the verbal responses and test responses of high school biology students as a result of training in higher level questioning of student teachers and to determine the relationship of higher level verbal responses to student teacher indirectness as measured by the Flanders' system. Higher level responses are those responses which are classified higher than the memory category in the Norris Sanders' Question Formulation.

Two groups of twenty-eight student teachers participated in the study. The experimental group was instructed in four classes in methods of science in the use of higher level questioning while the control group was subjected to a traditional treatment on questioning. Each student teacher taped a total of one hour of class time during the third, fifth, seventh and ninth weeks of a ten-week student teaching experience during which questioning was the major classroom activity. In addition, each student teacher administered a ten-question quiz during the fourth, sixth, eighth and tenth weeks of student teaching to one selected biology class where both testing and taping were conducted. The tapes and tests were then coded for the level of questioning using the Davis and Tinsley "Teacher-Pupil Question Inventory" and also the percentage of biology students responding correctly. The tapes were also coded using the Flanders System of Verbal Interaction Analysis to determine the I/D ratio for each student teacher. Differences in means of questions asked and percentages of correct responses between the two groups were analyzed using t tests. Pearson's r was used to determine the correlation between the I/D ratio and questions asked and percentages of correct responses.

The results obtained indicated that student teachers trained in the use of higher level questioning asked significantly (0.01) more high level questions (4.79 higher level questions per ten question quiz compared to 3.62 for the control group). Biology students responded correctly with equal success to higher level test questions (75.0% for the experimental group and 73.9% for the control; the difference is not significant at the 0.05 level). For verbal questions a similar result occurred. Student teachers trained in the use of higher level questioning asked significantly (0.01 level) more higher level questions than the control group (127 higher level questions compared to 83 for the four hours of taping for the control group). Again, biology students responded with equal success

to verbal higher level questions (77.8% for the experimental group as compared to 77.7% for the control group; the difference is negligible). Pearson's r for the following relationships was determined: I/D and higher level questions and I/D and correct higher level responses were determined at 0.86 and 0.35 for the experimental group; and 0.92 and 0.46 for the control group. The results indicated that biology student teachers who are instructed in higher level questioning ask more higher level questions and that biology student teachers who ask more higher level questions tend to be more indirect in their approach to teaching. The high school biology students respond correctly with higher level answers (indicative of higher level thought) about three-fourths of the time; but three-fourths of a significantly greater number of questions means more higher level thinking as evidenced by higher level responses on the part of high school biology students.

A STUDY OF THE EFFECTS OF TEACHER-QUESTIONING BEHAVIOR ON PUPIL CRITICAL THINKING ABILITY IN THREE ACADEMIC SUBJECTS OFFERED IN A SUBURBAN HIGH SCHOOL

Martin A. Cohen
New York University
New York City, New York

The problem of this investigation was to examine the classroom questions of teachers of tenth and eleventh grade science, english and social studies and to determine whether the frequencies and types of questions are related to changes in pupil critical thinking.

This investigation sought to provide data on the questioning behavior of teachers in their classrooms so that the relationship between questioning behavior and pupil critical thinking ability could be examined.

Teacher questioning behavior was identified from tape recordings made during the first twenty weeks of a school year. Each tape was of at least forty minutes of a class period and was analyzed using the nine category system of the teacher question inventory developed by Drew C. Tinsley and O. L. Davis. The investigator delivered a tape recorder and magnetic tape to each teacher before his class. The teacher was asked to turn the machine on after the attendance had been taken. Audio recordings of class sessions were analyzed and every question the teacher asked was classified and recorded. The questions were judged by their form and inferred intent as well as the nature of the response. A total of five class periods at approximately bi-weekly intervals were recorded over a twenty week period. A pilot study determined that it was not possible to institute a more rigid schedule of taping. This is due to such outside influences as teacher sickness or injury, jury duty, family obligations, conferences, etc.

The high school selected had approximately 3,200 pupils in attendance, and a faculty of 175 teachers. Both general and academic regents level courses were offered in each subject, as well as advanced or college equivalent courses. The primary focus of this study was aimed at the regents or academic levels which qualify a student to go on to college. Non-academic and advanced courses were excluded from this investigation. The selected sample of students were, therefore, composed mainly of those of average ability. D.A.T. scores for each student were available from the school records and were used in statistical treatment of the data.

Pupil critical thinking ability was measured near the beginning of the first semester of this investigation once classes had stabilized and again at the end of the twenty week observation period. The Cornell Critical Thinking Test, Level S, was used as a pre-test and post-test.

The data supplied by the analysis of the tapes and changes in pupil critical thinking scores provided the basis for a comparison of the independent variable, teacher questions, with the dependent variable, change in critical thinking ability.

AN EXPERIMENTAL STUDY OF A TELEVISED SCIENCE SERIES, GRADES 1-4, COMPARING THE QUALITY AND SEQUENCE OF TELEVISION AND CLASSROOM QUESTIONS WITH A PROPOSED STRATEGY OF SCIENCE INSTRUCTION

Paul Beisenherz
Louisiana State University
New Orleans, Louisiana

This study investigated the effectiveness of a televised science series in 54 classrooms, grades 1-4, in the Seattle metropolitan area. A factorial design was selected that provided a treatment variable representing four degrees of utilization of TV science and non-TV science. Teachers and their intact classes were randomly assigned to four treatment groups: I. Television science only, materials necessary for pre- and post-TV activities were provided; II. Television science and the regular district science program; III. Television science only; IV. Regular district science only. No special provision for materials was made for groups II-IV.

All questions asked by studio and classroom teachers were categorized into a multiple category system which included a modified Gallagher-Aschner system (intercoder reliability of .91), and the Science Lesson Category System that contained the pre-TV, post-TV, and non-TV categories. Also, all questions asked by studio and grades 3 and 4 classroom teachers utilizing TV science instruction were categorized into the Instructional Strategy Category System, a four-phased system--exploration, invention, discovery, and review. The ISCS evolved from an attempt to identify a model instructional strategy consistent with both exemplary elementary school programs and the nature of the scientific enterprise. Levels of significance between mean proportions of question types across grade levels, treatment groups and instructional contexts during and between the treatment period and the post-treatment period were analyzed.

Analysis of the questioning behavior of the studio teachers revealed a high proportion of convergent questions asked during the exploration and discovery phases at all grade levels. It was concluded that TV lessons in grades 3 and 4 did conform to the model instructional strategy. Sixty-three percent of the TV-related questions asked by classroom teachers in grades 3 and 4 were categorized into the discovery phase. In this phase, significantly more convergent questions were asked as compared to other question types.

Significantly higher proportions of convergent questions were asked by classroom teachers during the post-TV period while significantly higher proportions of memory questions were asked during the pre-TV period. Compared to non-TV science instruction, significantly higher proportions of convergent questions and significantly lower proportions of memory questions were found during the post-TV period. It was concluded that TV science instruction affected teacher questioning behavior.

This study was significant in several respects:

1. With the lack of studies concerned with the evaluation of educational television in relation to the questioning behavior of studio and/or classroom teachers, this study added a new dimension to the evaluation of instructional television.

2. The measurement of the extent to which this particular science series fostered thinking in pupils, through the questions it asks, and the extent to which it serves as a model for the transfer of questions it asks, and the extent to which it serves as a model for the transfer of question-asking behavior to the classroom teacher it serves, appeared to be similar to current research involving the "new" programs in elementary school science. This study, then, applied this means of evaluating a non-TV science curriculum to another source of science instruction, that of instructional television.

3. This study was significant not only in the development of model instructional strategies for elementary school science television programming, but in the development of instructional strategies for use in non-TV science curricula as well.

Session VIb - Student Characteristics, Envoy Room

Chairman: Sharon K. Wagner, Cornell University, Ithaca, New York

1. "A Comparison of Selected Wisconsin Secondary Schools Having High Per Cent Enrollment in Physics with Those Having Low Per Cent Enrollments in Physics in Terms of Certain Identified School, Teacher and Student Characteristics," Don Dietrick, Central Washington State College, Ellensburg, Washington, and Milton O. Pella, University of Wisconsin, Madison, Wisconsin.

2. "The Sociological Backgrounds of Scientifically Talented Secondary School Students Throughout the State of Texas," David R. Stronck, Washington State University, Pullman, Washington.

3. "The Relation of Wait-Time to Student Behaviors in Science Curriculum Study Lessons," Leonard J. Garigliano, Teachers College, Columbia University, New York City, New York.

A COMPARISON OF SELECTED WISCONSIN SECONDARY SCHOOLS HAVING HIGH PER CENT ENROLLMENT IN PHYSICS WITH THOSE HAVING LOW PER CENT ENROLLMENTS IN PHYSICS IN TERMS OF CERTAIN IDENTIFIED SCHOOL, TEACHER AND STUDENT CHARACTERISTICS

Don Dietrick
Central Washington State College
Ellensburg, Washington

and

Milton O. Pella
University of Wisconsin
Madison, Wisconsin

The purpose of this study was to compare selected Wisconsin secondary schools having high per cent enrollments in physics with those having low per cent enrollments in physics in terms of certain identified school, teacher, and student characteristics.

Per cent enrollment in high school physics was defined as the number of students enrolled in first year physics compared to the total twelfth grade enrollment. Schools with enrollments in physics of 25 per cent or more were considered high per cent enrollment (HPE) schools while low per cent enrollment (LPE) schools were those having no greater than 12 per cent in physics.

Selected for the study were 17 HPE and 18 LPE schools, 36 teachers of physics employed in these schools, 175 physics students, and 173 twelfth grade students who had not taken physics.

Data related to the identified school and teacher characteristics were collected utilizing questionnaires and college transcripts of the physics teachers. Data related to the student characteristics were collected by means of a questionnaire and interviews.

While many of the selected school, teacher, and student factors indicated a similarity between the two groups, some of the factors appeared to indicate enough differences between the two groups to warrant additional study.

The typical HPE school: (1) had a larger enrollment in grades 10-12 (856 to 653); (2) had a larger per cent of the 1969 graduates who went on to a four-year college (46 to 37); (3) had a smaller per cent (42 to 36) of the 1969 graduates who terminated their formal education with graduation from high school; (4) was more likely to provide the student an opportunity to take physics before the twelfth grade; (5) offered more courses (2 to 1) in physics; and (6) reported more science and fewer mathematics courses as prerequisites to the physics course than the LPE school.

The typical teacher of physics in the HPE school: (1) had earned a greater number of credits in science (96 to 89) and physics (35 to 24) and a smaller number of credits in chemistry (18 to 31); and (2) had a much higher probability of teaching only physics than the typical teacher of physics in the LPE school.

The physics students interviewed in the HPE schools: (1) who were planning to attend college, were less likely to plan a major in science and more likely to plan a major in a nonscience area; (2) had a high probability of receiving a physics grade less than their other science and overall grade point average; (3) were more apt to indicate that the physics teachers' general method of teaching was the most enjoyed aspect of the physics class; and (4) mentioned over twice as often that the counselor and only one-half as often that their parents or other science teachers were the source of advice to the students to enroll in physics, than the physics students interviewed in the LPE schools.

The interviewed twelfth grade students who had not enrolled in high school physics in the HPE schools: (1) who planned to attend college, much less frequently expressed plans to major in science or a science related area; (2) were less likely to avoid physics because of fear of failure or low grade; (3) expressed a lack of interest in science more often; and (4) expressed that they did not enjoy their last science course much more frequently than the nonphysics students in the LPE schools.

THE SOCIOLOGICAL BACKGROUNDS OF SCIENTIFICALLY TALENTED SECONDARY SCHOOL STUDENTS THROUGHOUT THE STATE OF TEXAS

David R. Stronck
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Pullman, Washington

The purpose of this study was to analyze the effects of five sociological conditions which are the circumstances of scientifically talented secondary school students throughout the State of Texas.

The instruments used in this study were a questionnaire and two examinations. Each examination was a reliable achievement test consisting of 50 questions (12 in physics, 19 in biology, 19 in chemistry). The 287 students in the experimental group resembled the 281 students of the control group because both groups consisted of high-ability students identified by their science teachers in randomly selected schools throughout the State of Texas. The study was essentially an analysis of the correlations between responses to the questionnaire and achievements on the examinations. To demonstrate the stability of these correlations the experimental group was compared to the control group.

The examination for the experimental group has a reliability coefficient of 0.85; for the control group, 0.78.

Both the experimental group and the control group showed significant differences at the 0.1% level among the mean scores of students from schools of different sizes. In both cases the sequence was the same: the larger schools always produced students with higher scores.

Both the experimental group and the control group had significant differences at the 0.1% level among the mean scores of students classified according to the size of the community in which the student lives. Both groups revealed the same ranking for the first three sizes of population: 1) 50,000 to 300,000, 2) over 300,000, 3) 10,000 to 50,000. The poorest scores were consistently from towns of under 1000.

For both groups the F ratios showed significant differences in the achievement of the students divided according to their future goals of employment. Students choosing physics or geology consistently scored well. Those who did not select a scientific field consistently did poorly.

For both groups the F ratios showed significant differences at the 2% level in the achievement of students divided according to the level of employment of the head of the household in which the student lived. When the head of the household was engaged in professional,

semiprofessional, or managerial work, the students consistently scored well. When the employment was skilled, unskilled, or in small business, the scores were low.

For both the experimental group and the control group the F ratios showed significant differences at the 2% level in the achievement of the students divided according to the classification of occupation of the head of the household in which they lived. Nevertheless the only consistent ranking shared by both groups was that poorer scores were achieved when the employment was in the categories of "outdoor" or of "service."

This survey demonstrates that larger schools, larger communities, the early selection of careers in certain scientific fields, and some types of employment held by the head of the household favor better achievement in modern science examinations by secondary school students living in the State of Texas.

THE RELATION OF WAIT-TIME TO STUDENT BEHAVIORS IN SCIENCE CURRICULUM STUDY LESSONS

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New York City, New York

Studies of classroom discourse conducted during the past sixty years have provided evidence of the existence of a fast pace phenomenon. Teachers allow very little "think space" as they ask questions, present material or respond to students. Descriptive studies indicate that the average wait-time in classrooms at all educational levels is between one and two seconds. The Science Curriculum Improvement Study because of its conceptual and open-ended inquiry orientation asks children to mentally process their interactions with materials. Discussions predicated on student-student interactions form an integral part of this program. Wait-time as an independent variable has received little attention by researchers. The problem of this study was to determine the effects of wait-time on student behaviors during Science Curriculum Improvement Study lessons.

To eliminate the mechanical problems encountered in working with entire classes and to maximize the impact of the independent variable, a modified microteaching model was utilized. The effect of wait-time on the number of: (1) content-oriented student solicitations; (2) inflected responses; (3) pupil-pupil interactions; (4) "I don't know" responses; and (5) the length of student response was studied.

Thirty-three elementary teachers from four SCIS Trial Center schools participated in the study. The subjects were selected by random numbers into three treatment groups of eleven teachers. Group I, the experimental group, received wait-time training, Group II functioned as a control group, and Group III was a placebo group that made only one tape recording per subject during the initial phase of the study.

Seventy-seven fifteen-minute microtapes were produced. The same four children, selected by the teacher, were used whenever more than one microtape was made by a subject. This procedure provided consistency in target population so that changes in teacher behavior from lesson to lesson might be detected by the children. Because this study was conducted in a school setting the teacher microtaught whichever SCIS lesson she had planned for that day. The modified microteaching model, here then, did not teach-reteach the same lesson but taught-retaught the same children. Child and teacher behaviors, not lesson types, were the substrate of this study.

Fifty-five tapes were selected for analysis. The thirty-three first microtapes from each group provided baseline data on the independent and dependent variables. Twenty-two third microtapes, eleven from the experimental group and eleven from the control group, were coded and analyzed. F-ratios were computed using the data from the three groups' first microtapes. No significant differences were found among the three groups on the independent variables of wait-time. Among the dependent variables only the mean length of student response showed a significant F-ratio on the baseline first microtapes from the three groups. Tests of significance (t-tests) were computed between Groups I and II (experimental and control) for both independent and dependent variables on the third microtape. Significant differences were found for the experimental group on mean overall wait-time, mean wait-time after teacher question and mean length of student response.

This study attempted to uncover relationships between wait-time and student behaviors during SCIS lessons. It was found that teachers were able to wait longer after asking questions. With the exception of longer student responses, and this is based on differences among groups at the outset, dependent variables did not achieve statistically significant levels. Methodological refinements are indicated. Using absolute wait-times proved too gross a measure in this study. Wait-times associated with various question types (i.e. convergent-divergent) may have more impact on student behaviors than measuring irrelevant pauses in the discourse. Only wait-times during discussion phases of SCIS lessons should be analyzed. Flexibility in teaching behavior given varying questions and lesson types may require more refined training techniques and the involvement of students in the feedback phases of the study.

Session VIc - Discussion Papers, English Room

Session VIc-1:
Chairman: Stanley L. Helgeson, Ohio State University, Columbus, Ohio

1. "Wait-Time and Rewards as Instructional Variables: Their Influence on Language, Logic, and Fate Control," Mary Budd Rowe, Teachers College, Columbia University, New York City, New York.

Session VIc-2:
Chairman: Wayne Taylor, Michigan State University, East Lansing, Michigan

2. "An Analysis of the Teaching Behaviors of PSSC and N-PSSC Physics Teachers and Their Effect on Student Cognitive Achievement in Physics," Virginia M. Petit, University of Michigan, Ann Arbor, Michigan.

Session VIc-3:

Chairman: Robert L. Steiner, Ohio State University, Columbus, Ohio

3. "Differential Response to Question Location in Learning from Written Materials in Science," John J. Koran, Jr., and Mary Lou Koran, University of Florida, Gainesville, Florida.

WAIT-TIME AND REWARDS AS INSTRUCTIONAL VARIABLES:

THEIR INFLUENCE ON LANGUAGE, LOGIC, AND FATE CONTROL

Mary Budd Rowe
Teachers College
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New York City, New York

The paper summarizes work of five years on influence of a variable called teacher wait-time on development of language and logic in children taking part in elementary science programs. Analysis of over 300 tape recordings showed mean wait-time to be on the order of one second. After a teacher asks a question students must begin a response within an average time of one second. If they do not the teacher repeats, rephrases or asks a different question or calls on others. A second potential wait-time is involved. When a student makes a response, the teacher reacts or asks another question within an average time of 0.9 seconds.

When mean wait-times of three to five seconds are achieved through training, analysis of more than 900 tapes shows changed values on nine student variables: 1. The length of responses increases. 2. The number of unsolicited but appropriate responses increases. 3. Failures to respond decrease. 4. Confidence as reflected in decrease of inflected responses increases. 5. Incidence of speculative responses increases. 6. Incidence of child-child comparisons of data increases. 7. Incidence of evidence-inference statements increases. 8. The frequency of student questions increases. 9. Incidence of responses from students rated by teachers as relatively slow increases.

Servo-chart plots of recordings show that students discussing science phenomena tend to speak in bursts with intervals of three to five seconds between bursts being fairly common. The average post-student response wait-time of 0.9 seconds apparently intervenes between bursts to prevent completion of a thought.

Over time a classroom on the prolonged wait-time schedule takes on other properties. Three teacher variables change: 1. Response flexibility scores increase; 2. Teacher questioning pattern becomes more variable; 3. There is some indication that teacher expectations for performance of students rated as relatively slow improves.

A model which involves the relation of wait-time and reward as input variables to language, logic, and fate control as complex outcome variables is discussed.

AN ANALYSIS OF THE TEACHING BEHAVIORS OF PSSC AND N-PSSC PHYSICS TEACHERS AND THEIR EFFECT ON STUDENT COGNITIVE ACHIEVEMENT IN PHYSICS

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The purpose of the study made by the author was to determine if certain teaching behaviors could affect student cognitive performance in physics. The main purpose was to examine the teaching behaviors of PSSC and N-PSSC physics teachers (those not teaching a PSSC physics course) and to determine if these behaviors were related to student cognitive performance on a physics content test.

The population of the sample consisted of eight PSSC and N-PSSC physics teachers and their physics students in Southeastern Michigan. Equal numbers of teachers taught the two physics courses, but 55 percent of the 368 students in the sample were taking the N-PSSC physics course.

The teaching behaviors of the eight PSSC and N-PSSC physics teachers were identified through data collected from three sources: (1) analyses of classroom interaction data, (2) analyses of teachers' oral and written questions, and (3) analyses of student perception of classroom activities.

Five instruments were used; three for teacher behavior data and two for student achievement data. The instruments used to gather data on teacher behaviors included: a verbal behavior instrument designed by J. R. Moore, an adaptation of a checklist of classroom activities by Leonard Kochendorfer, and an instrument derived from Bloom's Taxonomy of Educational Objectives. A physics achievement test written by the researcher supplied student data used in the study.

Six hypotheses were tested, five tested the significance of differences between the teaching behaviors of the PSSC and N-PSSC physics teachers and one tested the significance of differences in students' performance. A summary of the results follows:

(1) It was possible to identify significant differences between the teaching behaviors of the PSSC and N-PSSC physics teachers through the analysis of: classroom interaction, teachers' questions, and classroom activities.

(2) Most of the communication in the physics classroom was oriented to teacher-talk, but the PSSC physics teachers spent significantly more time asking or answering questions, hypothesizing or generalizing,

and significantly less time defining terms than N-PSSC physics teachers.

(3) The orientation of the physics classroom differed primarily in the amount of time spent in class discussion and supervised study with the PSSC physics teacher directing significantly more time to class discussion and significantly less time to supervised study than the N-PSSC physics teacher.

(4) The content of the communication in the physics classrooms revealed differences in the orientation of teaching objectives. The PSSC physics directed significantly more class-time to student discovery of relationships and significantly less time to verification of known conclusions and technology of consumer products than the N-PSSC physics teachers.

(5) The cognitive performance of the physics students on a physics test may be related to the cognitive levels of questions stressed by the physics teachers orally or on tests. The PSSC physics teachers asked significantly more oral and test questions at higher cognitive levels than N-PSSC physics teachers and the PSSC physics students performed significantly higher at all cognitive levels than the N-PSSC physics students on a physics test.

(6) There was little evidence of inquiry in the PSSC and the N-PSSC physics classroom as neither group spent much time on objectives related to the models or methods of science.

(7) Student perception of the frequency of selected activities in the physics classroom revealed significant differences. Significantly larger percentages of PSSC than N-PSSC physics students perceived having freedom in the laboratory, test questions at higher cognitive levels, and student directed activities.

(8) A teacher's philosphy rather than the influence of a particular curriculum may determine the teaching objectives and activities in his classroom. Findings from this study suggest a trend for the PSSC and N-PSSC physics teachers to use some of the objectives attributed to the other physics course as well as to reflect the objectives of the physics course they taught.

DIFFERENTIAL RESPONSE TO QUESTION LOCATION IN LEARNING FROM WRITTEN MATERIAL IN SCIENCE

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and
Mary Lou Koran
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Research has demonstrated that students learn more from prose passages when they are required to occasionally respond to questions inserted within this material (Rothkopf, 1966; Frase, 1968). This effect has been attributed to the control which questions exercise over "mathemagenic behavior", or the information processing behavior of the learner.

Learning of this type appears to be a function of the interaction of task variables such as position, pacing and type of question. There has been little evidence, however, to link these variables with learner characteristics. It is probable that the effects of certain task variables on learning from prose varies for different learners (ATI) (Cronbach and Snow, 1969; Koran, John J. Jr. and Koran, M.L., 1970).

The purpose of this study was to investigate the interaction of individual differences with question location in learning from science prose. It was anticipated that optimal question location would vary according to learner ability to process and store verbal information. Accordingly, verbal and short term memory abilities were expected to interact with question location (Koran, M.L. and Koran, J.J.Jr., 1972).

Following the administration of Verbal Comprehension, Associative Memory and Memory Span Tests selected from the ETC kit of Reference Tests for Cognitive Factors, 97 upper division science methods Ss were randomly assigned to one of three treatments in which questions were inserted: 1) before every two pages; 2) after every two pages, or, 3) were completely omitted from the prose passage (control).

Ss read the material and answered questions as they encountered them. A post-test measuring retention of the material was immediately taken by Ss at the end of the prose passage.

Experimental material consisted of a 5,000 word continuous prose passage on marine biology divided into 20 pages. From each page, two questions were prepared in a constructed response format. One of each pair of questions was inserted into the text. These twenty questions served as a post-test measure of information retention incidental to questions asked in the text. The 40 item post-test was given as a unit. Internal consistency reliability for the post-test was .81.

Relevant and incidental retention scores and reading time were analyzed separately using a one-way analysis of variance to

detect treatment main effects. For relevant retention both treatments receiving questions were found to be significantly more effective than the control ($p < .001$). For reading time, both experimental groups scored significantly higher than the control ($p < .001$) with the post-questions group scoring significantly higher than the pre-questions group ($p < .05$).

Simple and multiple regression analyses were used to evaluate ATI, using F - tests for heterogeneity of regression. These analyses indicated that the combination of aptitude variables used did not interact significantly with the treatments for the criterion variables. However, the positive relationship of verbal comprehension with performance in the control group, while unrelated to performance in both groups receiving questions suggests that the selective reinforcement of Ss' attention to specific aspects of the prose passage, such as names or technical terms, may reduce the burden of semantic processing and permit predictable information to be entered in short term storage until the end of each passage, thus providing a treatment condition in which the need for verbal processing is reduced and the role of short term memory effectively heightened.

A specific educational advantage of the effects observed is that they may suggest an effective alternative to conventional written-verbal instruction for less verbally able learners in science.

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Session VId - Instructional Methods and Materials, Regency Room

Chairman: Paul H. Joslin, Drake University, Des Moines, Iowa

1. "Factors Affecting the Implementation of the Laboratory Approach to Science Teaching in Grades K-3," Albert B. Carr, and John F. Emlaw, University of Hawaii, Honolulu, Hawaii.
2. "A Comparison of the Use of Outdoor vs. Indoor Laboratory Techniques in Biology to Prospective Elementary Teachers," William H. Chrouser, Barrington College, Barrington, Rhode Island.
3. "Teaching Fourth and Sixth Grade Science Using Laboratory-Theory Sequence and Theory-Laboratory Sequence Methods of Instruction," Charles M. Emslie, Graceland College, Lamone, Iowa.

FACTORS AFFECTING THE IMPLEMENTATION OF THE LABORATORY APPROACH TO SCIENCE TEACHING IN GRADES K-3

Albert B. Carr
and
John F. Emlaw
University of Hawaii
Honolulu, Hawaii

Major national science curriculum projects such as SCIS, S-APA, Minnemast, and ESS are materials centered, laboratory oriented programs. A review of the literature, however, suggests strongly that (1) practices in elementary science teaching have not been lab-oriented and (2) the difficulties encountered by teachers attempting to implement an effective science curriculum are more diverse than the single complaint that teachers do not know enough science.

The authors have conducted many science teaching workshops which emphasize present inquiry-discovery trends in elementary science education. Teachers and administrators are actively involved in materials-centered, laboratory-oriented activities. One of these workshops involved a group of 325 teachers and administrators from Oahu's 3-on-2 Program. Over a three-day period the participants worked with a wide range of material objects and organisms, and investigated temperature, magnetic, and chemical systems. The research described in this paper was undertaken in order to:

1. identify factors interfering with lab-oriented science teaching;
2. statistically treat these factors by
   a. ranking them according to significance as viewed by workshop participants,
   b. comparing teachers' views on significance with regard to teaching experience, and
   c. comparing administrators' views on significance with total group views;
3. discuss these factors and their statistical treatment and make recommendations which might lead to a greater implementation of lab-oriented science teaching.

The participants were asked to respond in writing to the following question: "What do you think are the major factors, problems, or reasons which tend to keep some teachers from implementing the kind of science program described in this workshop in their classrooms?"

From the many responses received, thirty-two statements were formulated which best represented the over-all attitude of the group. An attitude-scaling questionnaire was constructed from these statements and administered at the conclusion of the workshop.

Participants were advised on the questionnaire that some of the 32 items were probably more significant than others. Each partici-

pant was asked to rank each item regarding significance from a low of 1 to a high of 5. The Method of Successive Intervals was used for scaling the items. The method retains the simplicity of the equal-appearing intervals approach, yet the results are linearly related to those obtained by the method of paired comparisons over the complete range. The end scale values therefore have more meaning than the method of equal-appearing intervals, i.e., averaging.

The thirty-two items are listed in Table One in rank order according to the scale values assigned by the combined group. Also listed are the sub-group ranking and scale values for the 15 administrators, the 90 teachers with more than ten years experience, and the 222 teachers with ten years or less experience.

TABLE ONE

CG—Combined Group (327), A—Administrators (15), LET—Less-Experienced Teachers (222), MET—More-Experienced Teachers (90).

Rank Order		Scale Value	Item (and no. on questionnaire)
CG	1	2.43	There is presently a lack of materials for individual manipulation in schools. (29)
A	1	2.39	
LET	1	2.47	
MET	1	2.25	
CG	2	2.04	There is need for more money being available for science materials. (24)
A	13	1.45	
LET	2	2.15	
MET	2	1.92	
CG	3	1.94	There is a need for greater spending flexibility in purchasing materials. (25)
A	24	1.13	
LET	3	2.07	
MET	3	1.89	
CG	4	1.87	There is a need for appropriate curriculum guide for activities. (19)
A	4	1.74	
LET	4	1.92	
MET	7	1.71	
CG	5	1.85	Teachers are not sufficiently aware of locally available resources. (32)
A	8	1.51	
LET	5	1.91	
MET	5	1.78	
CG	6	1.73	There is a lack of storage space for manipulative materials. (30)
A	7	2.36	
LET	7	1.65	
MET	4	1.88	
CG	7	1.71	There is a need to know where science materials can be purchases. (26)
A	14	1.44	
LET	6	1.72	
MET	8	1.70	
CG	8	1.55	There is need for more workshops such as this one. (28)
A	7	1.67	
LET	10	1.50	
MET	6	1.76	
CG	9	1.51	There are not enough qualified consultants to help. (18)
A	5	1.87	
LET	9	1.51	
MET	13	1.46	
CG	10	1.49	Lack of teacher training in the area of discovery and "sciencing". (1)
A	5	1.71	
LET	11	1.46	
MET	11	1.49	
CG	11	1.47	The existing curriculum guides and this approach do not seem compatible. (20)
A	17	1.26	
LET	8	1.52	
MET	14	1.41	
CG	12	1.45	Feeling and concern that it takes too much time to acquire and organize materials for instruction. (15)
A	10	1.46	
LET	14	1.34	
MET	10	1.66	
CG	13	1.42	Lack of information about various programs, their end goals, and specified behavioral objectives for the children. (4)
A	9	1.47	
LET	12	1.44	
MET	12	1.48	
CG	14	1.40	There is a lack of space for children's active involvement. (31)
A	16	—	
LET	15	—	
MET	9	—	
CG	15	1.39	Lack of information in newer areas of contact, especially the physical and space sciences. (3)
A	6	1.67	
LET	13	1.43	
MET	16	1.35	
CG	16	1.25	Classes are too large for individual and small group work in science. (16)
A	19	1.19	
LET	18	1.18	
MET	15	1.40	
CG	17	1.23	There is not enough emphasis on science in most schools. (21)
A	11	1.46	
LET	16	1.22	
MET	19	1.22	
CG	18	1.23	There is need for more professional resource readings. (22)
A	15	1.36	
LET	17	1.20	
MET	17	1.33	
CG	19	1.13	There is need for more cooperation between teachers. (27)
A	25	1.13	
LET	19	1.10	
MET	18	1.25	
CG	20	1.05	Lack of evaluation techniques and devices to assess learning in this kind of situation. (9)
A	12	1.43	
LET	21	1.01	
MET	20	1.06	
CG	21	0.98	There is need to convince principal of merits of such a program. (23)
A	27	0.68	
LET	20	1.03	
MET	22	0.88	
CG	22	0.83	Lack of imagination and creativity. (5)
A	21	1.16	
LET	22	0.86	
MET	24	0.78	
CG	23	0.83	Insecurity with this approach to science, despite adequate training. (2)
A	20	1.18	
LET	23	0.80	
MET	23	0.85	
CG	24	0.74	Time available must be given to more important things such as reading and arithmetic. Sufficient time is not available for science. (14)
A	23	1.14	
LET	24	0.63	
MET	21	1.02	
CG	25	0.50	Actual fear or anxiety about experimenting or handling of live animals. (8)
A	22	1.16	
LET	25	0.45	
MET	27	0.56	
CG	26	0.44	Feeling and concern that the approach takes too much time. (13)
A	26	1.00	
LET	26	0.86	
MET	25	0.61	
CG	27	0.44	Teacher resistance to change in teaching approach. (10)
A	18	1.25	
LET	27	0.28	
MET	25	0.65	
CG	28	0.25	Lack of interest in this approach to science teaching. (6)
A	28	0.62	
LET	29	0.12	
MET	30	0.45	
CG	29	0.25	Feeling and concern that the approach is too noisy. (11)
A	30	0.44	
LET	28	0.14	
MET	29	0.46	
CG	30	0.18	Feeling and concern that this approach is too messy. (12)
A	29	0.59	
LET	30	0.06	
MET	32	0.40	
CG	31	0.16	The 3-on-2 Program does not really lend itself to this approach to science teaching. (17)
A	32	0.00	
LET	31	0.05	
MET	28	0.46	
CG	32	0.16	Lack of patience with such a program. (7)
A	31	0.20	
LET	32	0.04	
MET	31	0.43	

A COMPARISON OF THE USE OF OUTDOOR VS. INDOOR LABORATORY TECHNIQUES IN BIOLOGY TO PROSPECTIVE ELEMENTARY TEACHERS

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This study was designed to investigate and compare the effects of two laboratory approaches in biology upon prospective elementary teachers in their understanding of the social aspects of science, achievement in selected biological principles, understanding of science as process, and ability in critical thinking. The two approaches compared were the conventional indoor laboratory and the outdoor laboratory.

The subjects were students enrolled in the biology course designed for prospective elementary teachers at Colorado State College during the spring and summer quarters of 1969. The courses met for two hours per week for lecture and two hours back-to-back per week for laboratory. Each class was divided into an outdoor group and an indoor group. The place of the laboratory was the only known variable.

The Test on the Social Aspects of Science was used to measure gain in understanding of the social aspects of science. Methods and Procedures of Science: An Examination was used to measure gain in understanding of science as process. The Watson-Glaser Critical Thinking Appraisal was used to measure gain in critical thinking ability. Understanding of Selected Biological Principles: An Examination was used to measure gain in the understanding of the biological principles used in the study. Short quizes were given before and after each lab activity. The data were obtained by giving each of the instruments as a pre-test and post-test.

The Chi square analysis of scores on Test on the Social Aspects of Science showed significant differences in each of the three areas tested--namely, science and technology as they interact with society, nature of the scientific enterprise, and social responsibilities of science and scientists.

Analysis of covariance was used to analyze the gain in understanding of selected biological principles, understanding of science as process, and critical thinking ability. The F-tests for the significance of difference between adjusted means for the indoor and outdoor groups showed a significant difference at the 0.05 level of confidence in the specific biological principles involved in the laboratory activities and in the understanding of science as process. The F-tests for the biological principles in general and critical thinking showed no significant difference.

The investigator suggests when it is feasible and appropriate, that the outdoors be utilized as a laboratory and as a classroom, not

only because of the effect on society and the affective domain, but also because of the effect on the cognitive domain.

Informal follow-up observations have since been made in courses at Barrington College (Rhode Island) which varify the data and conclusions of the study. Courses in which field work and laboratory work were compared included ecology, botany, lower plants, higher plants and civilization, invertebrate zoology, vertebrate zoology, geology, cell biology, and comparative physiology. The Martine Biology Institute of Barrington College has resulted in very positive informal feedback as a result of the field work.

TEACHING FOURTH AND SIXTH GRADE SCIENCE USING LABORATORY-THEORY SEQUENCE AND THEORY-LABORATORY SEQUENCE METHODS OF INSTRUCTION

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The purpose of this study was to compare the relative effectiveness of teaching selected concepts associated with the study of atoms and molecules to fourth and sixth grade students by two contrasting methods. The two teaching methods were:

Method 1. Laboratory-theory sequence of instruction.
Method 2. Theory-laboratory sequence of instruction.

The sample of 99 students in the fourth and sixth grades of the Mount Ayr Community School system in Iowa were taught a science unit on atoms and molecules using Method 1, and 158 students in the fourth and sixth grades of South Harrison School District R-11 in Bethany, Missouri were taught the same science unit using Method 2.

A published test instrument designed to be used with a sixth grade science textbook was administered to measure achievement and retention.

Analysis of covariance techniques were used to analyze the data. The covariates were IQ and general science achievement.

The findings were as follows:

1. There was no significant difference in the total achievement scores for the fourth grade students due to the teaching sequence. The data indicated an overall tendency favoring the laboratory-theory sequence as the preferred method of instruction. It was assumed that the laboratory experiences created a high motivation for learning theoretical concepts.

2. There was no significant difference in the total achievement scores for the sixth grade students due to the teaching sequence. The data indicated that the sixth grade students more readily accepted the concepts without laboratory motivation.

3. This study indicated that the concepts associated with atoms and molecules were not learned adequately by the majority of fourth grade students in this sample.

4. This study indicated that sixth grade students in this sample were able to learn the concepts associated with atoms and molecules.

5. Retention of the concepts associated with atoms and molecules as measured by a delayed post test three months after the post test was extremely high.

6. This study indicated that sixth grade boys in the theory-laboratory sequence group scored significantly higher on the total post test items than the sixth grade girls in the same group.

7. This study indicated that there was no significant interaction between the treatment groups and IQ ability groupings.

CONCURRENT SESSION VII

Session VIIa - Verbal Behavior, Envoy Room

Chairman: Felicia E. West, University of Florida, Gainesville, Florida

1. "Classroom Applicability of the Stimulus Generalization Concept to Verbal Science Information," William G. Holliday, The University of Calgary, Calgary, Alberta, Canada.
2. "The Effect of Televised Science Instruction on Verbal and Nonverbal Process Behaviors of Teachers and Students in Grades 1-4," Jerry L. Tucker, Boise State College, Boise, Idaho.
3. "A Correlation of Teacher Self-Assessment and Student Perception of the Instructional Behavior of High School Biology Teachers," Alex J. Pogirski, Ann Arbor Public Schools, Ann Arbor, Michigan.

CLASSROOM APPLICABILITY OF THE STIMULUS GENERALIZATION CONCEPT TO VERBAL SCIENCE INFORMATION

William G. Holliday
The University of Calgary
Calgary, Alberta, Canada

Conway, in a review of multiple-sensory modality communication and sign differences, has seriously questioned the validity and the applicability of the stimulus generalization concept. He has called for rigorous school-relevant research in which the learning materials and the experimental setting more closely approximate that of the classroom. This multi-media instructional theory states that the learning of information increases as the medium or the delivery technique used in the testing situation becomes more similar to that used in the presentation. Hartman and Severin in their media research have supported this theory and assumed it to be valid without empirically investigating its appropriateness, according to Conway. As a consequence, an attempt has been made to clarify the usefulness of the stimulus generalization concept to secondary school students learning verbal science information.

The purpose of this study was to examine the question: Is the stimulus generalization concept applicable to school-relevant instruction if the material to be learned is verbal science information? The media or delivery techniques under investigation were audio, printed, and a simultaneous combination of both media.

Three hundred and thirteen tenth grade biology students were randomly assigned to nine subgroups. A variation of the posttest-only control group experimental design was used. Three hypothetical concepts in biology and a comprehension test for each were developed for this study in an attempt to prevent the verbal-printed component from singularly dominating the sensory channels of the learner. Each subgroup was presented the information through one of the three delivery techniques. Subsequently, each subgroup was tested over the presented information using one of the three delivery techniques. In other words, these nine subgroups were identifiable by the unique combination of media utilized for each in the learning and subsequent testing sessions. For example, the printed (learning) and audio-printed (testing) subgroup learned the science information by silently reading the text and were tested by silently reading the test and by simultaneously listening to the test read aloud. Both the learning and evaluative materials were presented using a programed text format group-paced delivery technique. A pilot program involving ninety-nine subjects was administered in a near-by school. The ETS ITEM ANALYSIS program was used to analyze the comprehension test questions and to revise the criterion test.

Analysis of covariance indicates that there was no advantage in using the same media in the learning and testing sessions. The Verbal Reasoning Test scores of the Differential Aptitude Tests served as the covariate scores. The resulting data were analyzed in two ways.

First, three analyses among the adjusted means of each testing media were made. Second, six a priori orthogonal comparisons of pairs of adjusted means were made. These findings question the extent of the theory's applicability and usefulness to meaningful prose material in science, especially where the instruction more closely approximates school-relevant conditions at the secondary school level.

THE EFFECT OF TELEVISED SCIENCE INSTRUCTION ON VERBAL AND NONVERBAL PROCESS BEHAVIORS OF TEACHERS AND STUDENTS IN GRADES 1-4

Jerry L. Tucker
Boise State College
Boise, Idaho

The purpose of this study was to assess the influence of process-oriented television science, grades 1-4, on teacher and student process and concept achievement, classroom teacher process questioning, and the relationship between achievement and questioning behavior.

During the 1969-70 school year, an experimental study was conducted to determine the influence of four combinations of KCTS-TV science and/or regular district science instruction on science process achievement and teacher questioning. Research hypotheses concerned the influence of treatment conditions on gains in teacher and student conceptual and process achievement; teacher process questioning during a three-month treatment period; and on the relationship between teacher background and teacher-student achievement and teacher questions during the study.

A factorial design utilized 54 volunteer teachers and their intact classes from four metropolitan Seattle school districts. Teachers were randomly assigned within districts and grades (1-4) to teach science under the following conditions:

I. TV "Ideal Conditions" only.
II. TV "Regular Conditions" and District Science.
III. TV "Regular Conditions" only.
IV. District Science only.

During a three-month treatment period, teachers in groups I, II, and III watched two KCTS-TV science units (Classification and Interpretation, grades 1 and 2; Change and Continuity, grades 3 and 4). Group IV taught regular lessons from the various district science curricula during this time.

All teachers and pupils were tested for conceptual and process skill achievement prior to and following the treatment period with instruments designed for the study and for teacher understanding of the nature of science with the Test on Understanding Science (TOUS).

Questioning behavior was obtained from audio-tape recordings made by all teachers of their instruction during the treatment period. Questions were categorized by trained coders using two systems; the Science Process Questions Inventory (SPQI) with categories for Recall, Observation, Measurement, Classification, Experimentation, Prediction,

and Miscellaneous questions; and the Science Lesson Category System (SLCS) with contextual categories of Pre-TV, Post-TV, and Non-TV. KCTS-TV science lesson script questions were also coded for comparative purposes. A total of 7300 questions were used in the study.

Teacher and pupil achievement gains, analyzed by unweighted means analyses of variance, showed only one significant difference between treatments: teacher mean TOUS gain scores favored "TV only" teachers at the .05 level.

Analyses of treatment-period questions found that all teachers asked about 1/3 recall, and 1/3 interpretation questions. Group comparisons indicated that "Non-TV" teachers asked significantly higher proportions of recall questions than "TV-using" teachers and significantly lower proportions of observation, classification, experimentation, and prediction questions than TV "Ideal Conditions" teachers. Comparisons of studio (TV) teachers and "TV-using" teachers showed statistically comparable proportions of classification questions posed. This study demonstrated that televised science instruction significantly influenced the types of science process questions elementary school teachers asked, usually favoring those using TV science under "Ideal Conditions".

The scarcity of research and practice aimed at systematically assessing science process competencies of teachers and children, and the sensitivity of the SPQI question category system to specific process operations inherent in scientific activities and in the Piagetian model of learning suggest further application of this system to both television and non-television instruction and research.

A CORRELATION OF TEACHER SELF-ASSESSMENT AND STUDENT PERCEPTION OF THE INSTRUCTIONAL BEHAVIOR OF HIGH SCHOOL BIOLOGY TEACHERS

Alex J. Pogirski
Ann Arbor Public Schools
Ann Arbor, Michigan

The primary purpose of this study was to determine verbal and procedural behaviors of Biological Science Curriculum Study (BSCS) biology teachers utilizing refinements of existing instruments. Further, the relationship between the teacher's perception of his behavior, the students' perception of their teacher's behavior, and the perception of a trained observer using interaction analysis was sought.

Ten public high school BSCS biology teachers and a class section with each teacher constituted the sample for this study. The students and teachers were from five different suburban high schools, located in three separate school districts within a radius of 50 miles from the University of Michigan, Ann Arbor. All teachers in the study were males; the students were boys and girls in the tenth grade.

Data on the perception of the teachers' instructional behavior came from three sources: the completion of check lists, by teachers, on how they perceive their verbal and procedural behaviors; the completion of check lists on the students' perception of their teacher's verbal and procedural behaviors; and the analysis of the classroom verbal interactions by a trained observer. The observer recorded four classroom and one laboratory sessions for each teacher.

It was possible to identify significant differences between the teachers' perception of their procedural behaviors and the perception of those behaviors by their students through the analysis of the teachers' and students' procedural check lists. There is, however, major agreement (about 87%) on the way students and teachers perceive the teachers' procedural behaviors.

All of the individual teachers and their students (ten out of ten) agreed on the rankings of their teacher's procedural behaviors, and eight out of ten teachers and their students agreed on the rankings of their verbal behaviors, as indicated by the significant correlations established between the individual teachers and their students.

The average teacher talked 61.68% of the total classroom time and 42.76% of the total laboratory time. In addition, the average teacher spent very little time in accepting, praising, or encouraging student ideas or behavior. Explicit statements about the limitations of knowledge and the nature of science almost never occurred in either the classroom or laboratory.

Teachers ranked themselves significantly higher than their students on (1) the acceptance and use of student ideas, (2) the rejection or criticism of student ideas, (3) the frequency of short factual questions and (4) the use of questions during the lab periods to help students discover their own answers.

On the procedural behavior check lists, students ranked their teachers significantly higher on (1) the emphasis their teachers place upon the learning of details from the text, (2) the emphasis of labeling drawings on tests, (3) the precise and definite interpretation of collected lab data. Teachers ranked themselves significantly higher than their students on the correlation of laboratory work with class discussion, lectures, reading assignments, testing (teachers perceive a greater correlation between lab work and other class activities than do their students).

On the correlations dealing with the perception of the teacher's behaviors between teachers and students, teachers and interaction analysis, students and interaction analysis on the verbal behaviors, and between students and teachers on the procedural behaviors, one teacher had all four significant correlations, four teachers had three significant correlations, four teachers had two significant correlations, and one teacher did not have any significant correlations on the verbal behaviors and had the lowest correlation coefficient of all ten teachers although significant on the procedural behaviors.

Session VIIb - Verbal Behavior, Ivy Room

Chairman: Roger Olstad, University of Washington, Seattle, Washington

1. "Kinetic Structural Character of College Physics Lectures," William L. Sharp, University of Iowa, Iowa City, Iowa, and O. Roger Anderson, Teachers College, Columbia University, New York City, New York.

2. "A Kinetic Structural Analysis of College Biology Lectures," Marjorie S. Muehlke, University of Pittsburgh, Pittsburgh, Pennsylvania.

3. "The Effects of Different Sources of Verbalized Information on Performance at a Science-Related Cognitive Task," E. 'Lanre Ogunyemi, University of Ibadan, Ibadan, Nigeria.

KINETIC STRUCTURAL CHARACTER OF COLLEGE PHYSICS LECTURES

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Iowa City, Iowa

and

O. Roger Anderson
Teachers College, Columbia University
New York City, New York

This study was proposed to determine the occurrence, stability, and character of kinetic structural patterns within college physics lessons. Kinetic structure is that parameter of teaching which considers the degree to which substantive information is arranged in accordance with an organizing principle, and is determined through the system of analysis proposed by O. Roger Anderson.[1] The purpose of the study was to determine the descriptive character of a random sample of thirty-six undergraduate physics lectures with respect to this parameter and to determine if specific styles of kinetic structural organization exist among the lectures of different teachers.

Six lectures were randomly chosen from the schedules of each of the six cooperating physics professors who were in turn randomly chosen from a population which satisfied criteria relative to academic preparation and native language. A transcription of audio-tape recordings of each lecture was prepared in accordance with the techniques prescribed by Anderson. The flow of discourse was broken into discrete "thought-segments" known as discourse units which were considered the units of analysis. Within each discourse unit substantive terms or phrases known as verbal elements were determined and assigned a code number for the purposes of computerization. A series of coefficients derived to determine the degree of structure within each lecture were then computed. Three parameters of structure considered were: a) commonality, the degree to which contiguous statements of discourse contain common verbal elements; b) progression, the degree to which the substantive content of a discourse statement diverges from that in the immediately preceding statement; and c) theme activity, the degree to which discourse centers about central "theme" elements.

Each lecture in the sample was so analyzed. The results provided an empirically based description of physics lectures at a level of preciseness unattainable prior to the development of kinetic structural analysis. A range of distinct modes of verbal organization was revealed among the cooperating professors. Statistically significant differences in structure were found between lectures on similar substantive material presented by different professors, whereas no significant differences were observed between lectures on different topics presented by the same professor.

Since kinetic structure affects knowledge acquisition[1,2] the results suggest that distinct modes of verbal organization place particular cognitive demands on the learner. As such, the discovery of kinetic structural "styles" now permits further studies to be conducted which can test the relationship between kinetic structure and other classroom phenomena such as student behavior changes and attitudes.

[1]O. Roger Anderson, Quantitative Analysis of Structure in Teaching (New York: Teachers College Press, 1971)

[2]A. Trindade-Khristanand, S. J., Structure in Science Teaching and Learning Outcomes (Unpublished doctoral dissertation, Teachers College, Columbia University, 1971)

A KINETIC STRUCTURAL ANALYSIS OF COLLEGE BIOLOGY LECTURES

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O. R. Anderson's system of kinetic structural analysis in teaching was used to assess content structure in thirty-six college introductory biology lectures. Anderson had previously analyzed junior high and senior high school science classes and had found a wide range among the mean fundamental coefficients of structure (B_1). Whether such differences were due predominantly to the nature of the subject taught, the individual teaching, or the student population could not be assessed. In this study a less diverse group of teachers, students and subjects was considered. The questions asked were the following: Is the kinetic structure a biologist uses in presenting introductory biology to college students consistent, and is there consistency among different professors of introductory biology? (This was done in parallel with a similar study of college physics by William L. Sharp, University of Iowa.)

Three professors were randomly selected at each of two New York City universities, and six lectures of each were audio-taped. They were analyzed according to Anderson's procedures. Analysis of variance treatment indicated no significant differences ($F = 1.98$, $p = 0.12$) among the $\bar{B}_1$'s covered a smaller range (0.25 to 0.36) than Anderson had found. A t test between the $\bar{B}_1$'s of the highest and lowest structured lectures showed a highly significant difference ($t = 4.0$, p 0.005.) It is of interest that students in the high structure lectures were older, general studies students. The lowest $\bar{B}_1$ range (0.26 - 0.29.) The high structure lectures had the lowest mean number of new terms per sentence (0.66) while the low structure lectures averaged more than one new term per sentence (1.07.) The latter also used an average of more codable terms per sentence (4.0) than did any of the others. "Progression density" was highest (1.29) for the low structure lectures and next to lowest (0.99) for the high structure lectures.

Kinetograms - graphs generated from the weighted coefficients of structure (B_2) - showed all the different patterns Anderson had described. Secondary span determination and analyses using the parameters $\bar{B}_1$, $\bar{B}_2$, progression density, and theme term's frequency, balance and dispersion were done, and this information was examined together with the kinetogram trace. It was not possible to identify patterns that could be said to characterize a given lecturer or a given $\bar{B}_1$ value.

The conclusion is that differences in kinetic structure among these biology lectures was small and that a number of different combinations of span organization yield the same overall $\bar{B}_1$ values.

THE EFFECTS OF DIFFERENT SOURCES OF VERBALIZED INFORMATION ON PERFORMANCE AT A SCIENCE-RELATED COGNITIVE TASK

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Ibadan, Nigeria

This study investigated the cognitive effects of (a) subject's prior self-determined verbalization of correct information about a problem situation (two levels) and (b) subjects' prior exposure to various external sources of verbalized correct information about the problem situation (three levels), on their performance at tasks requiring the use of such information for successful solution. Since significant sex differences have been found among science pupils of comparable age, sex was treated as an organismic independent variable. There were therefore three sets of independent variables. The dependent variable was the subject's performance at tasks involving the multiple ordering of three variables, each varying to four degrees, arranged in a four-by-four matrix array.

The link between the independent and dependent variables is the differential effects of the various modes of information-input (visual and auditory) on the subjects' cognition as measured by their performance. The details of the theoretical rationale within the cognitive framework was fully established. Two directional hypotheses were postulated. (1) Subjects who verbalized the correct information would, on the average, perform better on subsequent relevant tasks than subjects who did not verbalize. (2) Subjects would profit differentially from different external sources of verbalized correct information. Those subjects who were exposed to the teacher as the source of correct information would perform better than other subjects.

A factorial experimental design was utilized: therefore the two directional hypotheses got translated into seven statistical hypotheses (three main effects and four interaction effects of the three sets of independent variables). These were tested in the null forms by a three-way ANOVA using a .05 alpha level for each hypothesis.

The subjects consisted of 159 fourth graders (79 boys and 80 girls) who had been exposed to the Science Curriculum Improvement Studies (SCIS program for two years. They came from an urban school in Manhattan, New York City. They were selected into the different treatment groups by stratified random sampling from the population of pupils in the six 4th grade classes in the school. Intervening variables like inter-class differences, subjects' IQ, motivation and previous experience were hopefully controlled by the sampling technique. As equal distribution of subjects per treatment group could not be achieved owing to some conditions in the school, the number of subjects per treatment varied from 12 to 14.

Each subject was treated in an individualized session that lasted about 40 minutes. Two trained female experimenters, assigned at random to the male and female subject groups, administered the sessions. The experimenters were not aware of the hypotheses of the study. A standardized protocol, some of it on audio-tape, specified and guided all the experimenter's relevant verbal and motor moves. The treatment cells (for each sex) were randomly selected. Also, the order in which each subject within each cell came up for experimental administration was randomized. The subjects were advised not to discuss their experiences with each other or anybody else during the period of the study which lasted six weeks.

The task materials consisted of sixteen cylindrical wooden blocks. The blocks varied four degrees each in height, diameter and color (blue) tone. The blocks were arranged in a four by four matrix array on a white plywood check-board that had been subdivided into sixteen 2-inch squares. The subjects would have to recognize the spatial relationship of the properties (variables) of the blocks within the matrix array in order to solve the task problems. Sixteen distractor blocks were used. The distractors were colored in such a way that the color variable was nonredundant with the height variable. The tasks were a modification of the tasks used by Brunner and Kenney. There were three sets of tasks which varied in difficulty levels. These were replacement, reproduction and transposition tasks. There were a total of 12 tasks, all standardized in a previous pilot study. The scoring of each task was also standardized and was facilitated by the use of diagrammatic replicates of the matrix grid for each task on an individualized Record Sheet.

The hypothesis that the subjects who verbalized the correct information would on the average perform better than the subjects who did not verbalize the correct information was not supported. The hypothesis that the subjects would profit differentially from different external sources of verbalized correct information was supported for the female subjects but not for the male subjects. The main effect of supplying external information to the subjects contributed 4% while its interaction effect with sex contributed 15% to the subjects' performance.

It can be concluded that while it does not matter whether the teacher gives information to boys about materials in the classroom, it does matter with girls, as such teacher-supplied information considerably improves the changes of the girls learning and performing better at a cognitive task.

Session VIIc - Instructional Methods and Materials, Regency Room

Chairman: Kenneth D. George, University of Pennsylvania, Philadelphia, Pennsylvania

1. "Computer Supplemented Instruction in Secondary School Science: Implementation Proceedings and Survey Findings from a One-Year Program," William S. Donaldson, The Pennsylvania State University, University Park, Pennsylvania.

2. "An Analysis of the Comparative Effectiveness and Efficiency of the Dial Access Information Retrieval System with the Live Lecture and Printed Lecture Approaches to Teaching Selected Geological Facts, Processes, and Principles at the College Level," William R. Shirk, Shippensburg State College, Shippensburg, Pennsylvania, and H. Seymour Fowler, Pennsylvania State University, University Park, Pennsylvania.

3. "A Comparative Study of the Effect of Behavioral Objectives on Class Performance and Retention in Physical Science," Robert C. Olsen, Ridgewood Public Schools, Ridgewood, New Jersey.

COMPUTER SUPPLEMENTED INSTRUCTION IN SECONDARY SCHOOL SCIENCE: IMPLEMENTATION PROCEEDINGS AND SURVEY FINDINGS FROM A ONE-YEAR PROGRAM

William S. Donaldson
The Pennsylvania State University
University Park, Pennsylvania

Computer Supplemented Instruction is a process in which the student learns the conversational language BASIC and is directed to write certain computer programs. The purpose of this project was to construct a viable framework structured around emerging guidelines appropriate to cover potential administrator/staff implementation contingencies and crises. Also, the model was to include guidelines for prescriptive individualization of instruction following diagnosis and student-type identification. It was assumed that by making judicious use of the information collected, prescription could in fact be used to direct students into specific structured learning sequences, given their individual, preferential characteristics. It was supposed that certain student-types would not prosper when terminal usage became an integral component of respective courses-of-study. In general, however, students were expected to understand better that material (those processes) included in the CSI format. But computer-usage projects assume competent, meaningful, and judicious application selection and implementation by teachers more-or-less unfamiliar with computing techniques and potentials. A project where teachers were trained to be able to identify the "how's" and "why's" and founded on the CSI approach relative to computer-based activities in science was completed in the Spring of 1971 and is described below.

A Pennsylvania high school located in Titusville was selected as the experimental unit for the CSI Science Project, 1970-1971. Teachers of physics, chemistry, biology, and earth science were invited to Penn State for a summer workshop. None of the teachers in attendance during the three-week instruction period had any prior contact with computing operations, nor had any ever written a computer program. The summer session was designed to be, and was kept, most informal and open-ended. A scheduled section for presentation of computer language (BASIC) was held regularly. Penn State staff scheduled meetings with participants at which times discipline-specific computer applications were examined. With but one exception, participant programing-competence and application-proficiency transition was remarkable. These teachers returned to their district acquainted with the hardware, possible usage, etc., but hardly secure with respect to optional implementation. In degrees, each summer participant incorporated CSI into his course offering(s).

About 84 percent of the seniors surveyed indicated that--given their options--a science course with regular use of the terminal in the CSI format would be their preference. However, in other sections, student involvement seemed to be closely associated with the teacher's acceptance of the CSI proceedings. There is ample evidence to suggest that using the computer in the CSI fashion (1) increases interest among learners, (2) helps stimulate instructors to examine and revise their course offerings, and (3) serves to prepare most users for a life-style which embodies regular contact with encounters associated with computers.

AN ANALYSIS OF THE COMPARATIVE EFFECTIVENESS AND EFFICIENCY OF THE DIAL ACCESS INFORMATION RETRIEVAL SYSTEM WITH THE LIVE LECTURE AND PRINTED LECTURE APPROACHES TO TEACHING SELECTED GEOLOGICAL FACTS, PROCESSES, AND PRINCIPLES AT THE COLLEGE LEVEL

William R. Shirk
Shippensburg State College
Shippensburg, Pennsylvania
and
H. Seymour Fowler
Pennsylvania State University
University Park, Pennsylvania

The purpose of this study was to compare the effectiveness and efficiency of the various audio-video components of the Dial Access Information Retrieval System with the live lecture and printed lecture approach on students enrolled in the Basic Earth Science course at Shippensburg State College. Subproblems were:

1. What are the comparative effects of the audio, video, live lecture and printed lecture approaches of instruction on the replication, interpretation, and application levels of learning of geological facts, processes and principles as measured by the investigator-constructed test?

2. What are the comparative effects of the audio, video, and printed lecture approaches on the attitude of the students engaged in the respective instructional methods as measured by the investigator-constructed opinionnaire?

3. What are the comparative effects of the audio and video (via the DAIRS) approaches to learning on the attitude of the college teacher having access to the various media as measured by the Library Science opinionnaire?

4. What are the comparative efficiencies of the audio and video (via the DAIRS) and printed lecture approaches to learning with regard to the relative costs, time factor, student and faculty participation, complexity of operation, and flexibility of the system?

5. What are the comparative relationships of class standings, curriculum, major field, college board scores, and grade point average on test results in the live, printed, audio, and video treatments of the learning process?

The experiment was carried out over a two-week time period and consisted of one hundred college students being randomly assigned into four equal groups. The control group consisted of a live lecture approach, and the three experimental groups consisted of a printed lecture approach, audio lecture approach, and video lecture approach.

The purpose of the investigator-constructed test was to evaluate student learning at the replication level (identifying specific isolated facts), interpretation level (comparing, contrasting, and differentiating terms), and application level (reorganizing data, formulating hypotheses). Reliability of the 60-item test was computed to be .80.

The investigator-constructed opinionnaire asked students to react to the various treatments regarding preference, study time, and expected examination performance.

The Library Science opinionnaire surveyed the faculty of Shippensburg State College and requested information concerning faculty utilization, location sites for DAIRS, and strengths and weaknesses of the present installation.

Interviews were conducted and a continuous log was maintained recording the costs, time involved, and technical assistance required for all phases of the experiment.

Analysis of variance procedures were utilized throughout the entire study and F values were recorded as significant if the .05 level was attained. The following findings resulted:

1. The live lecture and video approaches were significantly more effective methods of learning at the replication level.

2. The live lecture approach was a significantly more effective method of learning at the interpretation level.

3. All treatments were equally effective at the application level of learning.

4. The video group recorded a greater proportion of favorable responses in all categories and the printed lecture approach showed a similar response over the audio treatment.

5. Many of the values and merits of the DAIRS are overlooked by faculty and students because of the existing technical problems.

6. The DAIRS is being used to its fullest capacity at Shippensburg State College.

7. Audio tape production was economical and required less preparation time than the printed or video lectures.

8. The cost of the audio and video lecture production decreases proportionately as student utilization increases, while the cost of the printed lecture increases slightly.

9. The analysis of data revealed no significant interaction existing among the various categories treated in the two-way analysis of variance.

A COMPARATIVE STUDY OF THE EFFECT OF BEHAVIORAL OBJECTIVES ON CLASS PERFORMANCE AND RETENTION IN PHYSICAL SCIENCE

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Ridgewood Public Schools
Ridgewood, New Jersey

This experiment was designed to assess the effects of behavioral objectives on class achievement and retention. Eight experimental classes received instruction in physical science (IME - Interaction of Matter and Energy) with stated behavioral objectives and six control classes received the same instruction without knowledge of the objectives.

The following research hypotheses were tested:

Hypothesis 1: The mean scores of classes studying IME science, as measured by an achievement test, will be higher for those classes provided with behavioral objectives prior to instruction than for those classes not provided with the objectives.

Hypothesis 2: The mean scores of classes studying IME science, as measured by a retention test, will be higher for those classes provided with behavioral objectives prior to instruction than for those classes not provided with the objectives.

Hypothesis 3: Within each of the three ability levels, high, medium and low, the group - level mean scores within those classes studying IME science, as measured by an achievement test, will be higher for those groups within classes provided with behavioral objectives prior to instruction than for those groups in classes not provided with the objectives.

Hypothesis 4: Within each of the three ability levels, high, medium and low, the group-level mean scores within those classes studying IME science, as measured by a retention test, will be higher for those groups within classes provided with behavioral objectives prior to instruction than for those groups in classes not provided with the objectives.

Behavioral objectives and their accompanying assessment tasks were constructed using the following nine action verbs: apply the rule, construct, distinguish, demonstrate, describe, identify, order, predict and state a rule. The subject matter used in this ninth grade investigation was the third unit of the science program, Interaction of Matter and Energy, published by Rand McNally

and Company. Four chapters (ten, eleven, twelve and thirteen) included subject matter in the areas of phases of matter, heat and light energy.

Research design number 10, proposed by Campbell and Stanley, was used in which the groups constitute naturally assembled classes. With this design, the treatment was randomly assigned to the pre-assembled classes.

Analyses of variance and covariance were used to analyze the data. Analysis of covariance was the technique used to adjust for pre-test differences between the experimental and control groups on the dependent variables. I.Q. and the STEP test scores were used as covariates. The dependent variable measures in this experiment were the mean scores obtained by fourteen classes on the following instruments: (1) STEP - Sequential Test of Educational Progress, Science-Series II, Form 3A; (2) Otis-Lennon Mental Ability Test, Form J; (3) IME - Interaction of Matter and Energy quarterly and final achievement tests.

Hypotheses one and two were supported by the data. The experimental classes obtained higher mean scores than the control classes on both achievement and retention tests. The overall mean differences due to the treatment was found to be statistically significant at the 0.01 level of confidence.

Hypothesis three, dealing with achievement within ability levels (high, medium, low), tested by analysis of variance, indicated acceptance at the 0.01 level of confidence across all three ability levels.

Based on the findings of this study, the following conclusions may be drawn:

The results of the study support the thesis that providing classes with behavioral objectives prior to instruction can enhance the performance on achievement tests. Also, the data strongly suggest that behavioral objectives and their accompanying assessment tasks will cause a resistance to forgetting.

Within the limitations of this investigation, the results and conclusions suggest that further consideration should be given to the behavioral objective approach to instruction and learning.

Session VIId - Discussion Papers, English Room

Session VIId-1:
Chairman: J. Myron Atkin, University of Illinois, Urbana, Illinois

1. "Assessing Curiosity and Problem Solving Behaviors Among Children: Some New Clues from the Analysis of Sensory Motor Responses," Rita W. Peterson, University of California, Berkeley, California.

Session VIId-2:
Chairman: Patricia E. Blosser, Ohio State University, Columbus, Ohio

2. "The Ability to Control Variables in Pre and Early Adolescent Children," Ted Bredderman, State University of New York, Stony Brook, New York.

Session VIId-3:
Chairman: Milton Pella, University of Wisconsin, Madison, Wisconsin

3. "The Retention of Science Concepts after a Period of Six Months by Students in High School Biology, Chemistry, and Physics, as a Function of Selected Student and Teacher Variables," Martin W. Haindl, Jersey City State College, Jersey City, New Jersey.

"ASSESSING CURIOSITY AND PROBLEM SOLVING BEHAVIORS AMONG CHILDREN: SOME NEW CLUES FROM THE ANALYSIS OF SENSORY MOTOR RESPONSES"

Rita W. Peterson
University of California
Berkeley, California

Because curiosity and problem solving are complex behaviors, educators cannot afford to accept unidimensional techniques of assessment nor simplistic explanations for these essential intellectual functions to the processes of science. Written and pictorial tests continue to provide the primary source of information about these behaviors among elementary school children; yet a large measure of the curiosity and problem solving behavior of these children is expressed through physical activity or sensory motor responses.

A study of the sensory motor responses associated with curiosity and problem solving (i.e., sensory imput coordinated with physical movement directed toward specified objects) was undertaken to learn more about the developmental nature of these intellectual functions. An environment was created to foster the natural expression of these behaviors. A hidden camera recorded behavior on video tape to permit delayed and multiple analysis. Children (N=125) in approximately equal numbers from both sexes and racial-ethnic groups (Black, non-Black) participated from kindergarten, second, fourth and sixth grades.

Children were invited to a waiting room filled with curiosity-arousing objects and instructed to do as they wished. When left alone, the amount of curiosity they exhibited correlated in significant way with predictions made by their classroom teachers. Curiosity assessed through sensory motor responses was scaled according to levels: 1 - Approaching, 2 - Manipulating, and 3 - Reorganizing objects. At 15-second intervals, 20 observations of each child's response level was recorded. Scores were generated which permitted comparisons among groups that differed in age, sex, racial-ethnic origins and Piagetian stages.

Multivariate and univariate analyses of variance indicated that the amount of curiosity expressed increased among age groups when children were left alone in a waiting room but remained constant among age groups when an adult was present. Black children exhibited significantly more curiosity than non-Black children. No significant difference was found between sexes. A slight positive correlation was found between curiosity scores and Piagetian stages.

The children were subsequently offered an assortment of keys and a puzzle box secured by three padlocks, thus permitting a comparison of curiosity and problem solving behaviors. Problem solving was analyzed according to strategy levels used to open the box, and ultimate success regardless of strategy.

Problem solving and curiosity behaviors were not found to be correlated. Analyses of variance indicated the use of logical strategies to solve the problem increased with age but did not vary between sexes or racial-ethnic groups. The number of locks opened, regardless of strategy, increased with age groups, and boys were significantly more successful than girls. No significant difference was found between racial-ethnic groups. Successful solution of the problem was significantly associated with Piagetian stages.

The present results differ in a number of ways from those reported by other investigators. When curiosity and problem solving behaviors were analyzed in terms of sensory-motor responses toward concrete objects, children's behavior varied in some ways not predicted by written and pictorial tests. Clearly, research is now needed which will clarify the nature of these differences found among various measurement techniques.

THE ABILITY TO CONTROL VARIABLES IN PRE- AND EARLY ADOLESCENT CHILDREN

Ted Bredderman
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Stony Brook, New York

Inhelder and Piaget have found that when European children were presented with the task of demonstrating the relationship between an independent and dependent variable, they did not control (separate) extraneous variables if more than one or two were involved, until twelve to fourteen years of age. They report that the preadolescent child of 6 to 10 years old is able to recognize correspondences between an independent and dependent variable. The authors further contend that because the development of abilities, such as controlling variables require a fundamental change in the logic used by the child they cannot be accelerated to any significant extent through a few contrived instructional experiences.

The study reported on here attempted to answer three questions with regard to the ability to control variables.

1. At what age do children from upper middle class communities develop the ability to control variables?

2. Does the elementary science program in the school they attend produce a noticeable effect on this development?

3. Is there a relationship between a child's ability to control variables and his ability to form combinations of variables?

Three schools in upper middle class communities with distinctly different elementary science programs were identified. The three programs could be described as (1) no coordinated science program, (2) science specialist laboratory program and (3) Science - A Process Approach with controlling variables as a specifically defined objective. A random sample of twenty children each in grades 4, 6, 8 and 10 was drawn from each school. Each of the 240 children was then individually presented tasks designed to assess their ability to form combinations of variables and to control variables.

The combinatorial task, required the subject to construct wooden men of varying hat, jacket, trouser and shoe color. From a limited selection of parts he was asked to construct as many different men as he could. The number constructed was recorded and his approach was categorized as "random", "partially systematic" or "systematic". The controlling variables task, required the subject to respond to six questions each of which asked him to demonstrate the effect of an independent variable on a dependent variable. The apparatus consisted

of a lever system in which values for five independent variables determined the value of a dependent variable. The number of variables properly controlled was corrected for guessing in arriving at a measure of the number of variables deliberately controlled.

Effect of school and age. An analysis of covariance was carried out, with the test score reflecting the number of variables controlled deliberately as the variate and IQ as the covariate. The results indicated no significant differences ($p = .05$) among science experience groups ($F = 2.3$, 2 and 18 df) and examiner groups ($F = 1.8$, 3 and 18 df), nor was there a significant interaction effect ($F = 1.1$, 18 and 191 df). There was, however, a significant ($p << .01$) difference between grade levels ($F = 20.0$, 3 and 18 df).

Relationship of combinatorial and controlling variables ability. For the combinatorial task subjects were divided into those who did construct or calculate the correct number of men and those who did not. The distribution among the three controlling variables ability categories indicated in Table I results from this division.

		Controlling Variables Ability Categories (Range of Scores)		
		(-30–+6) Poor	(7–18) Moderate	(19–30) High
Combinatorial Performance	Incorrect	27	60	72
	Correct	1	9	71

Table I: Number of Subjects in each controlling variables ability group giving a correct and incorrect response to the combinatorial task.

These data reveal a significant relationship between the placement of subjects in ability groups for controlling variable and their ability to form combination ($x^2 = 31.5$, 2 df, $p << 0.01$). This relationship is even more noticeable when subjects in each of the three ability groups for controlling variables is distributed among the three ability categories for the combinatorial task. Only the students who performed relatively well on the controlling variables task performed well on the combinatorial task. Or put another way, few, if any, students who did poorly on the controlling variables task did well on the combinatorial task.

In general there was a high intercorrelation ($p << .01$) among the various measures of performance on the two criterion tasks. Grade level, age, IQ and mental age also had high correlations with these performance measures. By and large the correlation of sex with task performance measures was not significant ($p > 0.05$).

These results support the conclusions that: (1) There is a significant improvement in the ability to control variables among children during the pre- and early adolescent years, (2) This improvement does not appear to be significantly affected by the nature of the science program used during the upper elementary grades, and (3) Rather than the combinatorial ability being a prerequisite to the ability to control variables as Inhelder and Piaget report, the reverse may be true.

THE RETENTION OF SCIENCE CONCEPTS AFTER A PERIOD OF SIX MONTHS BY STUDENTS IN HIGH SCHOOL BIOLOGY, CHEMISTRY, AND PHYSICS, AS A FUNCTION OF SELECTED STUDENT AND TEACHER VARIABLES

Martin W. Haindl
Jersey City State College
Jersey City, New Jersey

The purpose of the study was to determine a relationship between Science Concept Retention by high school science students in BSCS Biology, CHEMS Chemistry, and PSSC Physics and each of the following variables: I.Q., Sex, Science Achievement, Natural Science Development, Reading Comprehension, Quantitative Thinking, Delay Avoidance, Work Methods, Teacher Approval, Education Acceptance, Student Perception, of Teacher-Student Interaction (I/P), and Teacher Indirect to Direct Ratio (I/D), six months after the completion of the respective courses.

Furthermore, the purpose was to determine the combination of variables which was most predictive of Science Concept Retention in the individual sciences, and the combined sciences.

A total of 401 science students consisting of 175 biology students, 129 chemistry students, and 97 physics students were selected at random from the classes of four biology, chemistry, and physics teachers. The population consisted of average and above-average middle and upper-middle class, suburban American high school students from grades 9, 10, and 11.

Data for each of the twelve listed variables were collected for each student during the 1970 Spring semester. Neither the students nor the teachers had prior knowledge that retention of concepts in the sciences was to be measured in December 1970, six months after the completion of the respective courses.

Analysis of the data established relationships between Science Concept Retention and independent variables for the combined sciences, and separately for the individual sciences. Lower and upper limits of intervals of correlation coefficients between each of the independent variables and the dependent variable were determined such that it can be asserted that the probability is 0.95 that the population correlations are in the intervals. Furthermore, stepwise multiple regression analysis developed regression equations for the prediction of Science Concept Retention for the combined sciences, and each of the individual sciences.

1. For all students in the combined sciences it was found that strong relationships existed between over-all Science Concept Retention and each of the variables: Quantitative Thinking, Work Methods, Delay Avoidance, and Reading Comprehension. The relationship between over-all Science Concept Retention and each of the

affective variables -- Teacher Approval, Education Acceptance, I/P and I/D -- was low.

The combination of five variables which was most predictive of over-all Science Concept Retention and which yielded a multiple correlation of 0.81 included: Quantitative Thinking, Reading Comprehension, over-all Science Achievement, Work Methods, and Education Acceptance.

2. Strong relationships existed between Biology Concept Retention and each of the variables: Work Methods, Quantitative Thinking, Delay Avoidance, and Natural Science Development. Slightly weaker relationships exist between Biology Concept Retention and each of the variables: Reading Comprehension and I/D.

   The combination of five variables which yielded the greatest multiple correlation of 0.88 with Biology Concept Retention included: Work Methods, Quantitative Thinking, I.Q., I/D, and Reading Comprehension.

3. A strong relationship existed between Chemistry Concept Retention and each of the variables: Work Methods, Quantitative Thinking, Reading Comprehension, and Delay Avoidance. Moderately strong relationships existed between Chemistry Concept Retention and each of the variables: I.Q., and Natural Science Development.

   The combination of five variables which produced the greatest multiple correlation of 0.87 with Chemistry Concept Retention included: Work Methods, Quantitative Thinking, I.Q., Chemistry Achievement and Reading Comprehension.

4. A strong relationship existed between Physics Concept Retention and each of the variables: Reading Comprehension, Physics Achievement, Natural Science Development, Quantitative Thinking, I.Q. and Work Methods.

   The combination of three variables which produced the greatest multiple correlation of 0.72 included: Reading Comprehension, Physics Achievement, and Natural Science Development.

Evidence was obtained that in general the predictive value of each of the cognitive variables and I.Q. on Retention of Science Concepts for the combined sciences and the predictive value of the cognitive variables and I.Q. on the Retention of Science Concepts in the individual sciences was high. In general, the predictive value of each of the affective variables and sex on Retention of Science Concepts for the combined sciences and the predictive value of the affective variables and sex on Retention of Science Concepts in the individual sciences was low.

EVENING SESSION

Symposium On Environmental Education - English Room

Organized by the NARST Committee on Environmental Education

Chairman: Nathan S. Washton, Queen's College of City University of New York

Co-Chairman: Kenneth Jerkins, Morgan State College, Baltimore, Maryland

Participants: Gladys S. Kleinman, Jersey City College, New Jersey

Thomas E. Van Koevering, University of Wisconsin, Green Bay

George T. O'Hearn, University of Wisconsin, Green Bay

CONCURRENT SESSION VIII

Session VIIIa - Teacher Preparation, Regency Room

Chairman: Joseph H. Jacobs, John Jay College of Criminal Justice, CUNY, New York

1. "Training Pre-Service Science Teachers for Laboratory Instruction Using ISCS Microteaching Sessions," Richard J. Rezba, Indiana University, Bloomington, Indiana.

2. "Individualized Modular Instruction and an Instructor Directed Approach to the Preparation of Elementary School Science Teachers: A Comparative Study," Richard L. Butt, and Marvin T. Wideen, University of Saskatchewan, Regina, Saskatchewan, Canada.

3. "Relationships of Teaching Patterns to Indices of Classroom Verbal Interaction Behavior," Albert C. Bosch, New York University, New York City, New York.

TRAINING PRE-SERVICE SCIENCE TEACHERS FOR LABORATORY INSTRUCTION USING ISCS MICROTEACHING SESSIONS

Richard J. Rezba
Indiana University
Bloomington, Indiana

Increasing emphasis by recent science curriculum projects on student laboratory work makes it essential that science teachers develop appropriate patterns of verbal behavior conducive to maximum pupil achievement in the laboratory. The shift from illustrative to inquiry-oriented laboratory activities requires a change in the science teacher's role. He must be less of a transmitter of knowledge and more of a director of learning activities. If science teachers are to elicit the desired inquiring behaviors from students, they must first become predisposed to and skilled in the use of those verbal behaviors thought essential to this elicitation.

The purpose of this study was to determine whether a system involving a model of appropriate laboratory teacher behaviors and a micro-teaching environment would cause pre-service science teachers to acquire or to modify a pattern of verbal behavior thought complementary to the ideas of indirectness and deemed appropriate for inquiry-oriented laboratory activities and experiments.

Data for the study were collected from two groups of secondary science methods students on the verbal behavior exhibited while in the role of laboratory instructor during ISCS microteaching sessions. The verbal behavior exhibited by participants in experimental group I was recorded before and after instructional treatment. The verbal behavior exhibited by the participants in experimental group II was recorded on two occasions following instructional treatment.

The instructional treatment consisted of a printed model of laboratory teacher behaviors and a perceptual model employing these behaviors. The participants practiced classifying the behaviors used in the perceptual model and were provided with descriptions of laboratory situations to which they could formulate their own reactions.

Major conclusions include:

1. The instructional treatment cause a significant increase in the use of indirect verbal behaviors on ten of the fourteen indirect criterion variables for experimental group I.

2. There was a significant increase in the ratio of indirect to direct verbal behavior for experimental group I as a result of the instructional treatment.

3. The instructional treatment significantly decreased the use of lecturing by the participants of experimental group I.

4. There were no significant differences in the use of any of the verbal behaviors measured on the nineteen criterion variables between tests 1 and 2, both of which followed the instructional treatment, for experimental group II. This indicated a high degree of stability of participants' verbal patterns following instructional treatment.

5. There were significant differences attributable to high- and low-flexibility, as measured by the Philosophic-Mindedness Scale, on one criterion variable for group I and on three criterion variables for group II.

INDIVIDUALIZED MODULAR INSTRUCTION AND AN INSTRUCTOR DIRECTED APPROACH TO THE PREPARATION OF ELEMENTARY SCHOOL SCIENCE TEACHERS: A COMPARATIVE STUDY

Richard Butt
and
Marvin T. Wideen
University of Saskatchewan
Regina, Saskatchewan, Canada

Over the years much attention has been directed at individualized instruction at all levels. The purpose of this study was to compare an individualized modular instruction (IMI) approach to a directed approach in teaching an introductory science methods course.

The IMI approach involved the use of modules, audio-tape presentations, audio-tutorial materials, library research and other activities. These were made available to the students who were expected to determine their own course organization and emphasis. While the instructor and lab assistant were available in the IMI laboratory for periods equal to that spent with the other treatment group, their roles involved responding to students' requests for information, guidance, assistance in finding materials and the conducting of occasional seminars. This group did not have regular, scheduled classes.

The instructor-directed approach involved lectures and laboratories conducted with a minimum of individualization. Each topic or activity was pursued by the class as a group on a schedule determined by the instructor.

The two treatments differed in student role and teacher role; steps were taken to control other variables. For example, the two groups had equal access to all reading and curricular materials. The laboratory assistant and technician who were normally employed to assist the classes divided their time equally between the two groups.

Both treatment groups were given similar class objectives and content areas. The grading procedure was contracted for every student in each of the two groups. Two faculty members not involved with the teaching of the course made periodic observations of the treatment conditions and class offerings (course outline, experiences, instructor's log, etc.) to insure that extraneous variables were minimized.

The subjects of the study were 84 undergraduate students enrolled in two sections of an introductory science methods course for prospective elementary teachers. The two sections were randomly divided and assigned to the treatment groups during the first class meeting.

A pilot study was conducted during which time instruments were developed and validated. A formative evaluation was conducted on both treatments at this time.

The two groups were compared on the basis of their understanding of science processes, their knowledge of course content, their attitude toward science and science teaching, the type of science teaching attempted during student teaching, use of library and other resources. These data were collected by an evaluator independent of the project itself.

An analysis of covariance was used in a factorial design employing treatment, GPA, six, and other attributes as main effects. The result of the study will be presented in the paper.

RELATIONSHIPS OF TEACHING PATTERNS TO INDICES OF CLASSROOM VERBAL INTERACTION BEHAVIOR

Albert C. Bosch
New York University
New York City, New York

The purpose of this investigation was to determine which of ten selected behavioral indices were most sensitive in distinguishing between high and low i/d lessons and to establish relationships between teaching patterns and levels of interaction behavior through the re-analysis and synthesis of Flanders classroom verbal interaction data contained in four studies.

The four studies used in the investigation contained data from 39 teachers and 374 lessons. Eight representative sound tapes from each study were selected and recoded to establish coding reliability between the investigator and the original observers. A Scott coefficient of reliability of 0.85 was considered a reasonable performance level. After reliability was established, interaction data from the lessons was processed by a computer to separate each teacher's lessons into a high i/d (i/d = .5 or above) grand matrix (Matrix I), a low i/d (i/d = below .5) grand matrix (Matrix II), and a composite matrix (Matrix III). Each of ten selected indices of interaction behavior were then computed for Matrices I, II, and III. The ten behavioral indices were:

1. I/D Ratio (sum of columns 1-4 ÷ sum of columns 1-7),
2. i/d Ratio (sum of columns 1-3 ÷ sum of columns 1-3 + 6-7),
3. S/T Ratio (sum of columns 8-9 ÷ sum of columns 1-9),
4. E i/d Ratio (sum of columns 1-3 x rows 1-3 ÷ sum of columns 6-7 x rows 6-7 + sum of columns 1-3 x rows 1-3),
5. I/R Ratio (sum of column 9 ÷ sum of columns 8-9),
6. SS/TT Ratio (sum of 8-8 + 9-9 cells ÷ sum of columns 8-9),
7. A/I Ratio (sum of column 3 ÷ sum of columns 1-4),
8. A/D Ratio (sum of 3-3 cell ÷ sum of 3-3 + 6-6 cells),
9. S/A Ratio (sum of 3-3 cell ÷ sum of column 3),
10. A/C Ratio (sum of 3-3 cell ÷ sum of 3-3 + 7-7 cells).

A chi square test was performed for each of the ten indices for Matrix I compared with those of Matrix II for significant differences at the 0.05 level. A sensitivity test was then performed for significantly different indices by dividing each index in Matrix I by the comparable index in Matrix II. Average sensitivities were calculated and rank orders were established for the teachers in each study.

Teaching Pattern Analysis (Amidon and Amidon) was performed on all the matrices and major teaching patterns were extracted for comparison with indices of behavior.

The most sensitive behavioral indices were Indices 1, 2, 4, and 8.

When high i/d and low i/d matrices were compared, those behavioral indices which differed significantly at the 0.05 level were higher for the high i/d matrices than the low i/d matrices 91.5% of the time. The only exceptions were for Indices 6 and 7.

The most common teaching patterns were the 4-8-5 (23.44%), 4-8-3 (21.88%), and 4-8-4-9 (4.69%) sequences which accounted for 50.01% of all major teaching patterns. Of the remaining 24 teaching patterns, 5 occurred only twice (3.13% for each pattern type) and 19 occurred singly (1.56% for each pattern type).

The teaching patterns for the high i/d matrices were found to differ significantly (.02 level of confidence) from those in the low i/d matrices.

Although no significant relationships could be established between the most common teaching patterns and behavioral indices, those teachers who used identical patterns for their high and low i/d matrices generally had the lowest behavioral index rankings.

The high sensitivities of behavioral indices 4 and 8 should make them valuable measures of interaction behavior, especially in distinguishing between teachers with similar i/d ratios. Researchers should consider their possible use in future investigations.

No significant relationships could be established between the most common teaching patterns and the most sensitive behavioral indices.

One of the problems may be that the pool of data available for the investigation was not sufficiently large enough to establish the necessary relationships. Although the total number of tallies was large (236,148), only 61 teaching patterns could be extracted and analyzed.

Continued research into teaching patterns and indices of classroom verbal interaction behavior using larger samples of data is recommended.

Session VIIIb - Teacher Preparation, English Room

Chairman: Robert G. Bridgham, Stanford University, Stanford, California

1. "A Model for the Pre-Service Training of Science Teachers Based on the Intentions and Perceptions of First Year Science Teachers," Francis P. Collea, California State College, Fullerton, California.

2. "Teacher Corps Preservice: A Study of Change in Science Teaching Behavior," John T. Wilson, and John J. Wilson, Jr., and Mary Lou Koran, University of Florida, Gainesville, Florida.

3. "The Relationship Between Psychological Readiness and Achievement on a Computer-Assisted Instructional Program for Science Teacher Education," Louis A. Gardner, Georgia State University, and David P. Butts, University of Texas, Austin, Texas.

A MODEL FOR THE PRE-SERVICE TRAINING OF SCIENCE TEACHERS BASED ON THE INTENTIONS AND PERCEPTIONS OF FIRST YEAR SCIENCE TEACHERS

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The first year of teaching is a critical one for most teachers. Despite the importance of the first year of teaching, relatively little research has been done concerning the first year teacher. In order to evaluate and revise present teacher preparation programs, objective information about relevant first year teacher attributes is needed. An important set of factors are the intentions, self-perceptions, and role perceptions of the beginning science teacher. During pre-service training, the new teacher may have developed an idealized picture of his role in the classroom. Does the first year science teacher actually teach in accordance with his perceptions of role and self? Do his perceptions of role and self change during the first year of teaching? Is his verbal behavior in the classroom consistent with his perceived behavior? This writer conducted a study to answer these questions by carefully monitoring the intentions, perceptions, and classroom verbal behavior of first year science teachers. The results of that study were as follows:

1. The intentions of first year science teachers were in conflict. These science teachers increased their desire to motivate students, and yet, they decreased their desire for student participation in classroom activities. While increasing their intentions to justify their authority in the classroom, these teachers also increased in their desire to use more indirect behaviors in the classroom.

2. The role perceptions of first year science teachers were also in conflict. These teachers felt their principals wanted them to encourage and praise students more, but at the same time to use more criticism to justify their authority in the classroom.

3. By the end of the school year not only did first year science teachers perceive themselves as being more direct, but actual observations of their classroom behavior indicated they were more direct. At the end of the school year these teachers perceived themselves as motivating students less and having less student participation than they had at the beginning of the school year.

This study gives an objective measure to the perceptual and behavioral changes that a science teacher undergoes during his first year of teaching. These results can be used as a method of assessing the effectiveness of teacher preparation programs in influencing the verbal behavior patterns of first year science teachers. Once intentions and perceptions are determined and any changes noted, these changes can be compared to the perceptions of the principal and science supervisor. This kind of information could be valuable when planning teacher training programs. If it is found that role perceptions are significantly related to verbal behavior then science educators could gear their training programs accordingly. If not, another aspect of the teacher training program could receive greater attention.

TEACHER CORPS PRESERVICE:

A STUDY OF CHANGE IN SCIENCE TEACHING BEHAVIOR

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Teacher Corps Interns have a unique task. They enter schools as intern teachers without any pedagogical experience and little, if any, training other than their BA's in various academic areas. In order to facilitate this a six week, performance-based preservice training program precedes the actual school year, and is designed to provide interns with particular teaching skills.

The purpose of this study was to evaluate the effects of the microteaching portion of the preservice Teacher Corps Program, which had as its basis the acquisition of particular teacher behaviors considered to be related to teaching science to black and brown students.[1,2] The training procedure employed a combination of video-audio tape modeling sessions and written models[3,4] along with microteaching practice, and feedback and reinforcement on performance.[5]

Twenty-five interns were assigned to randomly selected groups of four students each for a microteaching pretest. Each intern was provided with the same Science - A Process Approach lesson on graphing and told to teach the lesson to the students for ten minutes. Prior to each session the interns were given set induction materials telling them that the behaviors that will be evaluated were: assessing entering behavior, evaluating instruction, teacher instructions, establishing set, reinforcement, and observation-classification eliciting questions. Subsequent to the pretesting, interns were subjected to training experiences for two days a week for six weeks. At the end of this time a post-microteaching session occurred to measure changes in the frequency of the aforementioned behaviors.

Teaching sessions were audiotaped and later rated. Three raters were assigned audiotapes randomly and rated them with inter-rater agreement ranging from .70 to .95. The Direct-Difference Method[6] of calculating the changes in mean scores when working with correlated data was used to analyze the data.

Of the six target behaviors for this training program, three significantly increased in frequency: assessing entering behavior (p .01); evaluating instruction (p .05); reinforcement (p .05). Two behaviors: teacher instructions and set showed no significant change, and observation-classification questioning behavior approached significance (p .08).

A number of research studies have demonstrated the efficiency of the techniques used in training science teachers.[7,8,9] The evaluation of the preservice Teacher Corps Program is further support for these training methods under actual field conditions and also indicates their relative efficiency. In areas of the nation where it is imperative to rapidly train beginning teachers and to retrain existing staffs, these methods appear to be highly recommended. In addition, it is imperative that expensive federal programs such as Teacher Corps justify their existance in terms of performance criteria. In this research project, the next step is to attempt to correlate student learning with particular changes in teacher behavior.

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THE RELATIONSHIP BETWEEN PSYCHOLOGICAL READINESS AND ACHIEVEMENT ON A COMPUTER-ASSISTED INSTRUCTIONAL PROGRAM FOR SCIENCE TEACHER EDUCATION

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The main purpose of this study was to determine if relationships existed among teaching experience, teacher concern level, and achievement of a skill used in teaching science. The science teaching skill selected for this study was the identification and use of behavioral objectives.

The study was conducted using a sample of 34 experienced elementary school teachers and 26 undergraduate elementary education majors. For the entire sample the range of teaching experience was from 0 to 36 years, and the range of teacher concern level was from zero to six on a seven-point scale. The subjects were involved with courses of teaching science to elementary school children. As part of the course, they participated in a computer-assisted instructional program, "INOBJ," designed to teach the identification and use of behavioral objectives.

Each subject was given a pre-test and a post-test on both the Teacher Concerns Statement and the Behavioral Objective Achievement Test. A minimum arbitrary competency criterion was established at 15 of 18 correct items on the Behavioral Objective Achievement Test. Six subjects met the minimum criteria on the pre-test and nine failed to reach the minimum competency level after instruction. These results indicate that students were generally successful in learning the identification and use of behavioral objectives when taught by the computer-assisted instructional program, "INOBJ."

The results of this study indicated that teaching experience is inversely related to achievement. This could suggest that the content being taught is of less importance to experienced teachers or that the content is not related closely enough to the actual classroom situation. Thus, experienced teachers tend to screen out material which they feel irrelevant to their past experience.

The significant correlations between teaching experience and teacher concern level support the inference that teacher concern level is a natural outgrowth of teaching experience. The longer a teacher teaches the more concerned he becomes with the activities of the students and the less he is concerned with his own adequacies or inadequacies.

The lack of correlation between teacher concern level and achievement of identifying and using behavioral objectives suggests that the concept of behavioral objectives is new to the teachers and not related to their concern level. Another inference is that teacher concern level is not a useful indicator of general psychological readiness. Rather, a specific concern about behavioral objectives might indicate a readiness to learn that specific skill. The data also revealed that teaching experience and teacher concern levels, when combined as a set, were not useful in predicting achievement in this study.

VIIIc - Instructional Methods and Materials. Envoy Room

Chairman: Marvin Druger, Syracuse University, Syracuse, New York

1. "The Relative Effectiveness of Inductively and Deductively Sequenced Modes of Teacher Centered Presentation in High School Chemistry," L. William Linz, and John W. Butzow, University of Maine, Orano, Maine.

2. "The Cassette Tape Recorder Means Versus Written and Symbolic Means of Providing Feedback of a Student's Performance on Secondary School Science Laboratory Exercises," Robert T. Tauber, and H. Seymour Fowler, Pennsylvania State University, University Park, Pennsylvania.

3. "A Comparison of Two Laboratory Methods for the Teaching of General Physical Science at the College Level: Vicarious Experimentation Versus Conventional Experimentation," Melvin O. Smith, Norfolk State College, Norfolk, Virginia, and H. Seymour Fowler, Pennsylvania State University, University Park, Pennsylvania.

THE RELATIVE EFFECTIVENESS OF INDUCTIVELY AND DEDUCTIVELY SEQUENCED MODES OF TEACHER CENTERED PRESENTATION IN HIGH SCHOOL CHEMISTRY

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Is sequence of presentation of material important in a realistic teacher-centered science classroom situation? Can an experimental design be created such that other researchers can faithfully reproduce the study? Secondarily, the questions of the interaction of sequence type with sex and sequence type with intelligence were explored.

The limiting case in difference of sequence of presentation is inductive vs. deductive sequencing. If learning is affected by type of sequence, a comparison of the effectiveness of the limiting case should certainly demonstrate it.

A unit on nuclear chemistry was arranged in a hierarchy from specific facts and observations toward increasingly complex, but more general, concepts. Every step was specified. A presentation starting with specifics and proceeding toward the larger, more general concepts was defined as inductive sequencing and the opposite direction as deductive sequencing. The test instrument consisted of short answer recall type questions and problem solving essay questions. It was administered as both pretest and post-test. The population consisted of 90 high school chemistry students in five classes from two schools in central Maine. The mean IQ of this population was 115 (Otis Gamma). The population was partitioned by treatment sequence, level of intelligence, and sex. The difference between the means of recall level test scores, problem solving level test scores, and total scores were tested for significance utilizing t-tests.

The results were that deductive sequencing is more effective if the total population is considered and, in most subgroups, defined by combinations of variables. In no case was inductive sequencing significantly superior. Deductive sequencing was particularly effective with the lower intelligence males. Sequencing is less important for females and makes no detectable difference with high IQ males. Deductive sequences are more important for developing problem solving skills than for teaching recall or factual material.

In situations where the teacher controls the classroom learning (as in most schools), according to the results of this study, he (she) would do best to use expository sequences, especially to teach problem solving. This is particularly important in the case of the slower male students. This study, together with its results, nicely fits Ausubel's models of learning. It also provides evidence for the efficacy of developing simple wholes into complex wholes as is predicted by cognitive learning theories.

THE CASSETTE TAPE RECORDER MEANS VERSUS WRITTEN AND SYMBOLIC MEANS OF PROVIDING FEEDBACK OF A STUDENT'S PERFORMANCE ON SECONDARY SCHOOL SCIENCE LABORATORY EXERCISES

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and
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The purpose of this study was to investigate the differences in performance scores on secondary school science laboratory exercises (dependent variable) that resulted from the students receiving a teacher's evaluation via one of four treatments or means of feedback (independent variable). The four means of evaluative feedback were: No Comment (NC) -- laboratory exercise returned with just a number or letter grade as an evaluation; Limited Comment (LC) -- laboratory exercise returned with a number or letter grade plus one word or short phrase teacher comments as an evaluation; Free Writing (FW) -- laboratory exercise returned with a number or letter grade plus, as a minimum, an additional one-half page of teacher comments as an evaluation; and Free Tape (FT) -- laboratory exercise returned with a number or letter grade plus, as a minimum, three to eight minutes of teacher comments via a cassette tape as an evaluation. This investigation was designed to determine if there was a significant difference, at the .05 level, in performance among the cassette feedback groups and the other feedback groups when the data from each laboratory exercise, from each class, from each discipline, and from all laboratory exercises, classes and disciplines are combined and analyzed.

The sample consisted of four teachers and 224 students from the tenth, eleventh, and twelfth grades making up twelve classes. Although the four teachers were selected on a volunteer basis, the author was able to randomly assign students within each class to the study and to a particular treatment or means of feedback. This resulted in having all four treatments being administered in each of the twelve classes. Although this allowed for the possibility of confounding effects among the treatments, it permitted the investigator to hold the teacher variable constant.

In order to combine the data from different laboratory exercises, classes, disciplines, and grade levels, and to avoid the assumption of normality among the variates, the investigator used the method of ranks proposed by Friedman (1937). The following statistical procedures were used:

1. A Friedman chi square (X^2) calculated on the ranks for each laboratory exercise, for each class, for each discipline, and for all classes and disciplines combined.

2. An analysis of variance $\underline{F}$ test calculated on the means of sums of ranks for each discipline and for the combination of all disciplines.

A COMPARISON OF TWO LABORATORY METHODS FOR THE TEACHING OF GENERAL PHYSICAL SCIENCE AT THE COLLEGE LEVEL: VICARIOUS EXPERIMENTATION VERSUS CONVENTIONAL EXPERIMENTATION

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and

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The purpose of the study was to compare the relative effectiveness of two laboratory teaching methods for college level general physical science; specifically, will students who study by vicarious experimentation achieve significantly better than those who study by conventional experimentation? The criterion instruments used in the study were: (1) Watson-Glaser Critical Thinking Appraisal; (2) The Sequential Test of Educational Progress--Form 1B; (3) Nelson-Denny Reading Test; (4) Welch Science process Inventory; and (5) The Smith Appraisal of Methods and Processes of the Scientists. The study also attempted to find answers to the question: Are differences in achievement related to the sex of the student and/or the student's academic major?

Two intact groups were used in the study. The groups were composed of non-science majors enrolled in general physical science courses at Norfolk State College, Norfolk, Virginia. All students attended weekly laboratory classes. One group performed a series of vicarious experiments, and the second group performed conventional experimentation which treated the same concepts. The study was conducted over a period of 15 weeks and followed the pre-test, post-test design.

An analysis of covariance was performed on data collected during the study. In this analysis the student's achievement in the understanding of science content as measured by The Sequential Test of Educational Progress--Form 1B and critical thinking ability as measured by The Watson-Glaser Critical Thinking Appraisal served as dependent variables. Scores from The Nelson-Denny Reading Test, The Smith Appraisal of Methods and Processes of the Scientists and Welch Science Process Inventory served as covariates. The Nelson-Denny scores were used in order to control reading. The influence of attitude and the student's ability to employ the methods and processes of scientists were controlled by scores recorded on The Welch instrument and The Smith instrument respectively.

On the basis of the analysis of covariance and the F test of significance, the following conclusions were reached:

1. The use of vicarious experimentation appeared to be more effective than conventional experimentation as a means of developing the student's ability to think critically.

2. The vicarious teaching method appeared to be significantly more effective than conventional experimentation as a means of promoting achievement in the understanding of science subject matter content.

3. Girls who studied by the vicarious laboratory method achieved significantly greater test scores than those who studied by the standard or conventional laboratory method.

4. The use of vicarious experimentation was more effective as a method of teaching students matriculating in the areas of special and elementary education.

5. Vicarious laboratory experimentation appeared to be essentially equivalent to conventional laboratory methods as a method of teaching boys and when used with business and social science majors.

The aforementioned facts emerge as most significant findings in the study because they provided the college physical science classroom teacher with an alternate teaching method. The teacher can now select the method of his preference without the fear of depriving the students of a chance to attain academic excellence and achievement. This alternate method of instruction will seemingly aid in the overall curricula program because it can be readily incorporated into small group or large group instruction and independent study assignments. Although this investigator did not run a comparative cost per student analysis, it was obvious that the cost of the standard laboratory method is vastly greater per student than the cost of conducting the vicarious laboratory experimentation.

Vicarious experimentation will hopefully provide the college physical science teacher with a new teaching device. Experiments which were heretofore inaccessible because of location or because actual experimentation would involve very long periods of time can be modified and presented to the students vicariously.

VIIId - Instructional Methods and Materials, Ivy Room

Chairman: Ruth P. Wellman, Marshall University, Huntington, West Virginia

1. "Direct and Indirect Instruction at the Community College and Its Relation to Achievement in the Cognitive Areas of Knowledge and Abilities," James Campbell, Reed University of Pennsylvania, Philadelphia, and Irwin Sayer (Deceased), and Cyrus W. Barnes, New York University, New York.

2. "Teaching Science Via a Socio-Historical Approach," Michael L. Agin, Michigan Technological University, Houghton, Michigan.

3. "The Effectiveness of the Discrepant Events Model in the Teaching of Science," Frank A. Johns, Cleveland State University, Cleveland, Ohio.

DIRECT AND INDIRECT INSTRUCTION AT THE COMMUNITY COLLEGE AND ITS RELATION TO ACHIEVEMENT IN THE COGNITIVE AREAS OF KNOWLEDGE AND ABILITIES

James Campbell
Reed University of Pennsylvania
Philadelphia, Pennsylvania
and
Irwin Sayer (Deceased)
and
Cyrus W. Barnes
New York University
New York City, New York

The object of this research study was to examine the effect of direct and indirect teaching on achievement in the cognitive areas of (1) knowledge and (2) abilities in an introductory college biology course. Direct and indirect teaching was determined through Flanders' technique of verbal interaction analysis. The cognitive areas utilized in this study refer to the following cognitive domain categories (Bloom, et al., 1956): (1) Knowledge: a. knowledge of specifics, b. knowledge of ways and means of dealing with specifics, and c. knowledge of universals and abstractions in a field; (2) Abilities: a. comprehension, b. application, and c. analysis.

The study was conducted at Bronx Community College in the fall semester of 1967 with six biology instructors. The participating instructors were selected on the basis of their directness or indirectness as determined by a previous pilot study utilizing Flanders' ten category interaction analysis system. The three indirect and the three direct instructors covered the same curriculum and were audio-taped for five sessions each. This procedure resulted in the tabulation of an average of 4,763 tallies per instructor.

Achievement was determined by a test specifically developed for this investigation. Originally, the 158 item test was administered to 92 students and a detailed item analysis utilizing biserial coefficients and difficulty indices resulted in a test which had a reliability of r = .80. A jury determined the domain levels of the test.

All classes received a pretest and an IQ test at the onset of the study and a post test as the final exam. A one-way analysis of covariance was used to adjust all pretest or IQ inequalities.

Two findings were uncovered:

1. The two groups of teachers differed significantly in their verbal behavior (.01 level) as determined by a modified Darwin Chi-Square Test. The resulting five interaction ratios differed substantially.

2. No significant differences in achievement at either cognitive level were uncovered for the groups in terms of all interaction ratios.

As a final segment of the study the grand matrices produced at this grade level were compared to matrices of science instruction at other grade levels. This analysis showed that science instruction differed substantially on the junior, senior, high school and college levels. This finding is hypothesized to represent indigenous methodological differences at each of the three grade levels.

TEACHING SCIENCE VIA A SOCIO-HISTORICAL APPROACH

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Houghton, Michigan

The purpose of the study was to determine the feasibility of teaching science via a socio-historical approach utilizing selected concepts related to the social and historical development of science and selected concepts related to atomic energy. The criteria used to assess the success of the approach were:

1. A significant increase in subject matter knowledge possessed by the students participating in the study.

2. A high level of student interest toward the socio-historical approach as indicated by the responses of the students to an interest questionnaire.

3. An increase in the students' understanding of knowledge related to

   a. science and scientists

   b. science-society interrelationships, and

   c. the atom and atomic energy.

The materials used in the study included (a) 12 chapters of textual materials developed by the investigator, (b) an evaluation instrument based on the text, (c) a series of slides, and (d) four selected motion picture films. The investigator, who taught the instructional materials to two different high school populations during two separate 14-day periods of instruction, utilized a lecture-discussion technique with an accompanying slide presentation. The populations used in the study were 107 twelfth-grade students in American Problems classes (School A) and 76 tenth-, eleventh-, and twelfth-grade students in Chemistry classes (School B).

A 90-item multiple choice test, administered as a pretest and post-test to both groups, yielded three subtest scores (science and scientists, science-society interrelationships, and the atom and atomic energy) and a total score for each student. Mean gains (the difference between pretest and post-test class mean scores) for the subtests and total test were analyzed statistically and found to be significant for both schools.

Student responses to a questionnaire indicate that a majority of students in both schools expressed a positive opinion toward the interest producing potential of the unit and indicated that the reading material was at least at the same level of difficulty as materials experienced in science classes. In addition, at least 83

percent of the students of School A and 91 percent of School B indicated that the unit had increased their understanding of (a) science and scientists, (b) science-society interrelationships, and (c) the atomc and atomic energy.

On the basis of the conditions of the study and the procedures and nature of the populations utilized, it is concluded that teaching via a socio-historical approach is feasible. The approach can be utilized as an effective means of teaching the interrelationships of science and society as well as teaching other concepts related to science. In addition, the socio-historical approach to science instruction could be used to meet the needs of a large segment of the high school population not interested in a career in science but interested in examining more closely various facets of science and their social relationships by providing an alternative to the present methods of science instruction.

THE EFFECTIVENESS OF THE DISCREPANT EVENTS MODEL IN THE TEACHING OF SCIENCE

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The purpose of this study was to compare the relative effectiveness of the Discrepant Events Method and the conventional method of teaching general science. The difference in the treatment for the experimental classes is in the presentation of discrepant event demonstrations and the method of arriving at understanding the concepts and ideas presented. The Discrepant Event Method followed three specific steps:

1. Presentation of the discrepant event.
2. Student participation and hypotheses formation.
3. Discussion and summary.

An instructional profile of the control classes was determined by a daily questionnaire to determine the methods employed in these classes.

The population sample included eight classes with three different teachers. One teacher taught two experimental and two control classes while the other two teachers taught one experimental and one control class. All classes included in the study were 9th grade general science, heterogeneously grouped, and used the same textbook and curriculum guide.

The effectiveness of this method was studied in terms of three educational components: cognitive learning, retention of subject matter, and critical thinking ability. To compare differences in achievement in these three areas, two instruments were used; the Watson-Glaser Critical Thinking Appraisal and a specifically designed cognitive learning test which had sub-scales to differentiate between the learning of concepts, facts, and operations.

A pre-test of both instruments used to measure achievement was given at the onset of the study, which then proceeded in three phases. Phase one included the presentation of the first unit using the experimental and control procedures. A post-test of the cognitive learning test was given after four weeks upon completion of the first experimental unit. Phase two continued for seven weeks using the methods previously described. At the end of this experimental period, the post-test of the critical thinking instrument was administered. Phase three of the study was concerned with the retention of cognitive learning after sixteen weeks. The sixteen week period was chosen on the basis of information concerning the nature of the retention curve presented in the study. The cognitive learning instrument was then readministered, and for the purposes of this study was referred to as post-test II.

A three-way analysis of variance of cognitive learning scores allowed the investigator to determine whether learning did take place. The difference in performance between experimental and control classes based on gain scores between the first and second post-tests was also determined.

The technique of analysis of covariance permitted statistically equating the pre-test scores of the experimental groups on the Watson-Glaser Critical Thinking Appraisal and the pre-test scores of the experimental groups on the cognitive learning tests. The post-tests of both the critical thinking instrument and the cognitive test were then tested to determine significant differences between the experimental and control classes. A second analysis of covariance, performed to determine retention of subject matter, statistically equated the groups on the first post-test so that results could show significant differences between experimental and control post-test II scores.

One of the three sections of the cognitive test, as well as the total cognitive score, showed a significant difference for experimental conditions when statistically equating the pre-test of the experimental and control classes. The area of retention of subject matter showed no significant difference between experimental conditions on all parts of the cognitive learning test when statistically equating post-test I of the experimental and control classes. In the area of critical thinking, no significant difference occurred between experimental conditions on the post-test of the Watson-Glaser Critical Thinking Appraisal when statistically equating the pre-test of the experimental and control classes.

Results of the analyses of this study indicate that the Discrepant Events Method significantly affected achievement in the concept area of cognitive learning while maintaining equal achievement levels in facts and operations. Based on the evidence presented in this study, consideration must be given to include this type of instruction in general science when developing conceptual learning is the main objective.

GENERAL SESSION II

Chairman: J. David Lockard, University of Maryland, College Park, Maryland

Speaker: Dr. Harry Broudy, College of Education, University of Illinois, Urbana, Illinois

"Can Research Find A Rationale For Science Education?"